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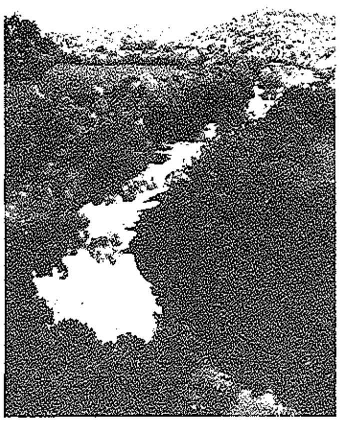

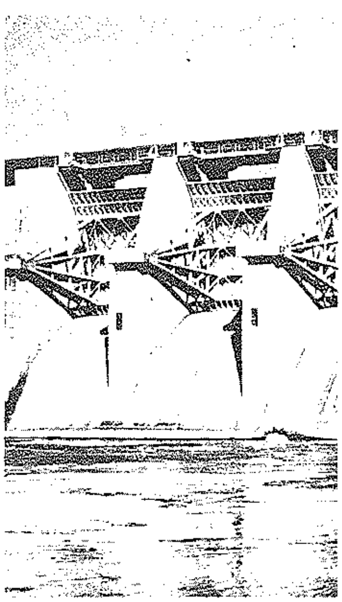

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WATER QUALITY STUDIES IN THE UPPER WATERSHED OF STEELE BAYOU, MISSISSIPPI

by

Steven L. Ashby, Thomas C. Sturgis, Cynthia B. Price
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13. ABSTRACT *(Maximum 200 words)*
Sediment and water quality sampling was conducted during a 1-year period at several locations in the watershed of Steele Bayou, Mississippi, to describe spatial and temporal trends. Physicochemical and biological water quality parameters displayed dynamic distribution patterns that were attributed to influences of hydrologic events, channel morphometry, hydrology, and local land uses.

Influences of hydrologic events were most obvious, with elevated concentrations of suspended material coincident with precipitation and runoff events. Pronounced material transport was suggested by relatively high values of total solids, total suspended solids, and total nutrients. Diel variations of dissolved oxygen concentrations and seasonally high concentrations of nutrients and chlorophyll *a* suggested a highly productive system, particularly in the downstream regions of Main Canal, Black Bayou, and Steele Bayou. An

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organic-rich system was indicated by relatively high dissolved organic carbon concentrations. Highly variable distribution of parameter concentrations during the summer low-flow period suggested that local conditions markedly influence water quality. Local influences of riparian vegetation were most apparent in evaluation of the phytoplankton community. In the canopied reach near Leroy Percy State Park, phytoplankton productivity was lower, and chlorophyll *a* concentrations were higher when compared to open reaches.

Insecticide and herbicide concentrations were detected occasionally in the surface waters of the study area; however, concentrations were generally near detection limits. PPDDD, PPDDE, PPDDT, and heptachlor were the most commonly detected pesticides in surface sediment samples. The highest average concentration of most pesticides was in the MC2 subwatershed. However, all pesticides were detected in low concentrations in surface sediments (<0.1 mg/kg).

14. (Concluded).

Agriculture	Sediment quality
Herbicide	Steele Bayou
Insecticide	Streams
Nutrients	Water quality
Organic carbon	Watershed

PREFACE

This report was prepared by the Environmental Laboratory (EL) of the US Army Engineer Waterways Experiment Station (WES), Vicksburg, MS, for the US Army Engineer District, Vicksburg (LMK), Vicksburg, MS. Personnel who cooperated in the execution of the study and preparation of this report include Dr. Judith C. Pennington, Project Coordinator, and Mr. Steven L. Ashby, Mr. Thomas C. Sturgis, Mrs. Cynthia B. Price, and Dr. James M. Brannon, all of the Aquatic Processes and Effects Group (APEG), EL. Project manager at LMK was Mr. Dave Johnson.

Collection of water samples, field analyses, and chemical analyses for routine water quality parameters were conducted by the US Department of the Interior Geological Survey, Water Resources Division, Jackson, MS. Mr. Larry J. Slack coordinated the effort.

Chemical analyses of water, soil, and sediment samples for pesticides, PCBs, and herbicides were provided by the Analytical Laboratory Group, EL, under the direction of Ms. Ann B. Strong. Mr. Harry L. Eakin, APEG, EL, coordinated the analyses for chlorophyll *a*.

The report was prepared under the general supervision of Dr. Thomas L. Hart, former Chief, APEG, and Dr. Richard E. Price, Acting Chief, APEG; Mr. Donald L. Robey, Chief, Ecosystem Research and Simulation Division; and Dr. John Harrison, Chief, EL.

COL Larry B. Fulton, EN, was Commander and Director of WES. Dr. Robert W. Whalin was Technical Director.

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CONTENTS

WATER QUALITY STUDIES IN THE UPPER WATERSHED OF STEELE BAYOU, MISSISSIPPI

PART I: INTRODUCTION

Flood control measures, such as the construction of weirs, channel clearing, and rerouting of water, have been proposed for the Steele Bayou (SB) drainage basin. Proposed flood control measures are anticipated to alter hydrologic processes and potentially impact water quality in the basin. Flood control measures may also provide opportunities for environmental enhancements in the basin. Evaluation of potential impacts on water quality in Steele Bayou drainage basin as a result of proposed flood control measures is required for inclusion in an Environmental Impact Statement.

Water quality in the basin is generally considered to be poor due to excessive levels of turbidity, suspended materials, and nutrients; however, historical water quality data for the upper region of Steele Bayou are sparse. Little is known about the influence of physical features, such as the type and extent of riparian vegetation, channel morphometry, and land use of the immediate drainage area, on water quality in Steele Bayou. Additionally, dynamic hydrologic conditions influence water quality and material transport. Of particular concern is the transport and fate of agricultural insecticides and herbicides as a result of hydrologic changes. Recent studies (Winger et al. 1985; Ford and Hill 1991) suggest that biomagnification of selected organochlorine pesticides from sediments to aquatic organisms occurs within the basin. With the exception of organochlorine pesticide concentrations observed by Ford and Hill (1991), little is known about sediment quality.

Major objectives of this study were to describe distribution patterns of water and sediment quality and evaluate processes relative to water quality in different locations of the study area. Such information will allow assessment of potential project impacts on water quality for inclusion in the Environmental Impact Statement.

PART II: METHODS

Water and sediment quality studies were conducted from March 1990 through February 1991. Studies included routine monitoring of physicochemical parameters at monthly intervals, supplemental studies conducted seasonally, seasonal surveys of insecticide and herbicide concentrations, and an intensive survey of sediment quality. Specific routine water quality parameters, insecticides, herbicides, and PCB congeners analyzed in sediment samples are listed in Tables 1-3. Detailed methods for sample collection and analyses are included as Appendix A.

Selection of sampling stations was coordinated with the US Army Engineer District, Vicksburg (LMK), and the US Fish and Wildlife Service. Station location and sample type are depicted in Figure 1 and Table 4. Subwatershed boundaries were delineated by the LMK.

Routine monitoring was conducted at 11 stations that were selected for their proximity to features pertinent to the study (i.e. existing or proposed weir, channel morphometry, or land use of the immediate drainage area). Station SBS1 (Steele Bayou at Rolling Fork, Highway 14) is located in the pool maintained by the only weir in the study area. Station SBS3 (Steele Bayou at Hampton), downstream from Swan Lake (SL), was assumed to be characteristic of water quality for the majority of the study area, yet effects of impoundment from a weir can be differentiated by comparison with station SBS1. Station SBS5 (Black Bayou near Percy) provides data representative of water quality of Black Bayou (BB) and Granicus Bayou (GB) at the inflow to Swan Lake. The reach between station SBS3 and station SBS5 has been channelized and cleared except in the immediate vicinity of station SBS5. Station MCS1.5 (Granny Baker Bayou near James), located on Silver Lake Bayou, provides data representative of water quality of Main Canal (MC) as it enters Swan Lake near a new weir site (Weir E). Station BBS1 (Black Bayou at Highway 12), located within Leroy Percy State Park (LPSP), provides data representative of a reach of Black Bayou which flows through a forested and, therefore, canopied area. Station GBS1 (Granicus Bayou at Highway 12) is a secondary drainage channel into Black Bayou. The remaining five routine stations are located along Black Bayou and Main Canal and are representative of reaches which provide drainage for mostly open, agricultural areas and the city of Greenville. Station BBS2 (Black Bayou at Estill), station BBS3 (Black Bayou at Arcola), and station BBS7 (Black Bayou at Leland) are located on Black Bayou. Station MCS3 (Main

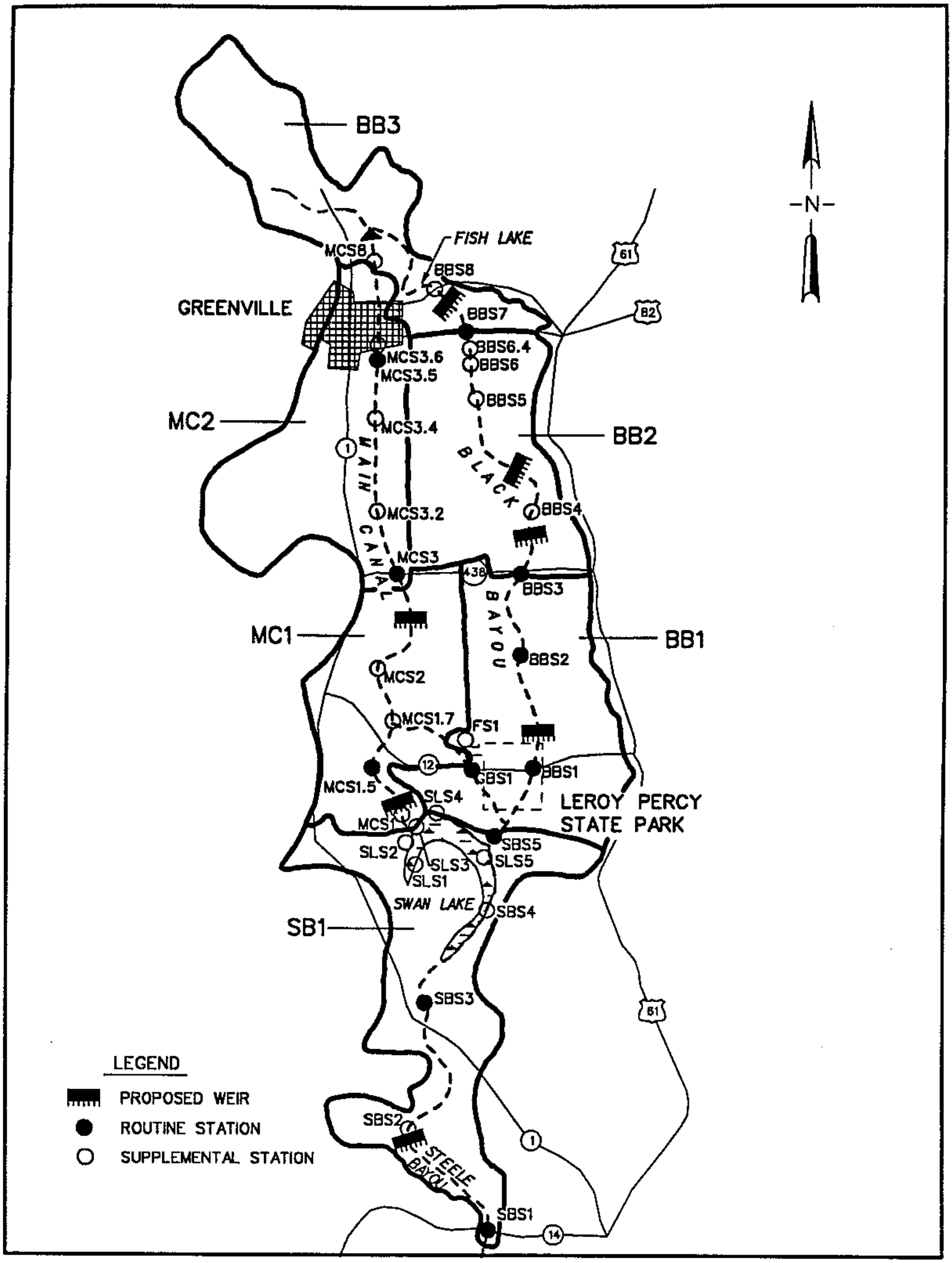


Figure 1. Station locations in Steele Bayou watershed. Large bold labels represent subwatersheds. Solid circles denote routine stations for water quality sampling. Hollow circles denote supplementary stations

Canal at Wayside) and station MCS3.5 (Main Canal at Swiftwater) are located on Main Canal.

Two intensive surveys of physicochemical parameters in each subwatershed were conducted to evaluate spatial variability within and among each subwatershed during low- and high-flow periods. In conjunction with the routine sampling trip in June 1990, 14 additional stations along the major drainage channels were sampled. Supplemental stations included SBS2 (Steele Bayou at Hopedale), SBS4 (Steele Bayou at Eifling), BBS4 (Black Bayou at Wilmont), BBS5 (Black Bayou at Wilmont), BBS6.4 (Black Bayou at Greenville), BBS8 (Fish Lake near Metcalfe), MCS2 (Granicus Bayou), MCS3.2 (Main Canal southeast of Swiftwater), MCS3.4 (Main Canal east of Swiftwater), MCS3.6 (Main Canal at Greenville), and MCS8 (Main Canal at Metcalfe). Station FS1 (unnamed ditch near James) in Black Bayou 1 (BB1) and stations SLS3 (Silver Lake) and SLS4 (#9 dredge ditch) in Steele Bayou 1 (SB1) were sampled to identify potential anomalies in secondary drainages but were not used in the evaluation of spatial variability. Limited access and low water resulted in sampling at only two stations in the Black Bayou 3 (BB3) subwatershed (station BBS7, Black Bayou at Leland on Highway 82, and station BBS8, Fish Lake near Metcalfe). Additional sampling at the same supplemental stations was also conducted coincident with routine sampling in January 1991, to evaluate spatial variability among and between subwatersheds during a high-flow period. Mean value, coefficient of variation, and Duncan's Multiple Range Test procedures were conducted on water quality data from these intensive surveys using the Statistical Analysis System (SAS) (SAS Institute, Cary, NC).

Phytoplankton productivity was evaluated at selected stations to assess variability between canopied and open reaches. Coincident with routine sampling in June, phytoplankton photosynthesis and respiration were determined using the light/dark bottle technique (American Public Health Administration (APHA) 1980). In situ incubation of triplicate samples was conducted in 300-ml clear (light) and opaque (dark) bottles at each site. Incubation periods were from 0900 to 1330, 1045 to 1745, and 1230 to 1830 (time in hours based on 2400-hr clock) at stations SBS1 (Steele Bayou at Rolling Fork), BBS1 (Black Bayou at Highway 12), and BBS3 (Black Bayou at Arcola), respectively. Dissolved oxygen (DO) concentrations were determined with the azide modification of the Winkler titration method (APHA 1980).

Photosynthetic and respiratory rates were calculated using the following equations:

Net photosynthesis = DO (light) - DO (initial)/length of incubation
Respiration = DO (initial) - DO (dark)/length of incubation
Gross photosynthesis = DO (light) - DO (dark)/length of incubation

Gross productivity was calculated for each station according to Vollenweider (1969). Total column depths were used in conversion of productivity from volumetric to areal rates to allow comparison between the relatively shallow stations. Daily gross productivity was adjusted for incubation periods asymmetrically spaced about midday using the equation from Stephens and Gillespie (1976). The length of day was considered to be 14 hr, and 1300 was considered local solar noon. Samples for routine water quality analysis and phytoplankton identification were collected at the onset of incubation. Phytoplankton samples were examined on an inverted scope and identified to genus.

Diel changes in temperature, DO, pH, and specific conductance were measured at selected stations in August. Selected stations represented a weir pool (SBS1, Steele Bayou at Rolling Fork), a reach upstream from a weir pool and downstream from a recently channelized reach (SBS3, Steele Bayou at Hampton), and two locations along an unchannelized reach through a canopied area (SBS5, Black Bayou near Percy, and BBS1, Black Bayou at Highway 12).

Levels of selected insecticides and herbicides were measured at routine stations in March, July, and October coincident with agricultural application. Additional stations located on secondary drainage channels in the vicinity of Swan Lake were sampled during July and October (stations SLS3, Silver Lake, and SLS4, #9 dredge ditch).

Current and historical sediment quality within the basin was determined based upon a survey of surface sediments at 20 stations in the drainage basin and core samples from six stations (Table 4 and Figure 1).

PART III: RESULTS

Field studies conducted during the period 1 March 1990 through 28 February 1991 included 12 sampling trips to routine water quality monitoring stations, three surveys of insecticide and herbicide levels, two intensive water quality surveys of 25 stations, a primary productivity study, a diel study, and a sediment survey of 20 stations. The hydrograph for Steele Bayou at station SBS1 (Steele Bayou at Rolling Fork) is provided for reference to hydrologic conditions during the study period (Figure 2). Data from the study are included as Appendix B.

Temperature, Dissolved Oxygen, pH, and Specific Conductance

Temperature ranged from 7.0 to 34.5 °C with highest temperatures occurring in June, July, and August. Dissolved oxygen concentrations ranged between 1.7 and 18.5 mg/l and were generally above 4.0 mg/l. Dissolved oxygen concentrations below 4.0 mg/l were most often observed during the summer at sampling times occurring early in the morning, while highest values occurred during the same season at stations sampled late in the afternoon. Values for pH were between 6.5 and 9.1 and indicate circumneutral waters. Specific conductance ranged from 57 to 950 μS/cm with highest values observed during summer low-flow conditions and lowest values occurring during high-flow periods (Figure 3).

Solids

Total solids ranged between 200 and 1,444 mg/l with values between 300 and 600 mg/l for most of the study period (Figure 4). Generally, total solids concentrations were relatively constant except for increased values observed during periods of high flow. The elevated value during April at station SBS5 (Black Bayou near Percy) may be attributed to construction activities associated with bridge repair at the station.

Suspended solids distribution was similar to that of total solids for the study period (Figure 4). Suspended solids ranged from 16 to 1300 mg/l and comprised the majority of the total solids during high-flow periods. Conversely, during periods of low flow, suspended solids decreased, and dissolved solids comprised the majority of the total solids.

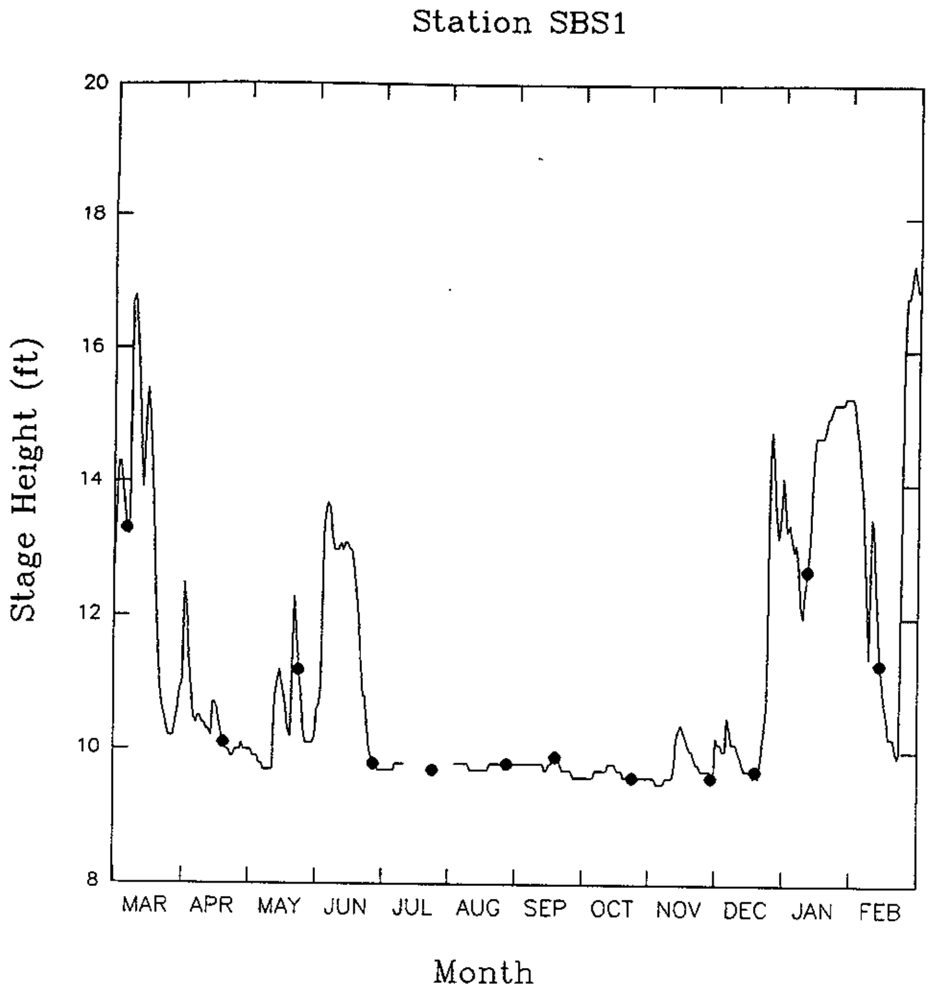


Figure 2. Hydrograph for the Steele Bayou watershed at station SBS1. Solid circles denote routine sampling trips

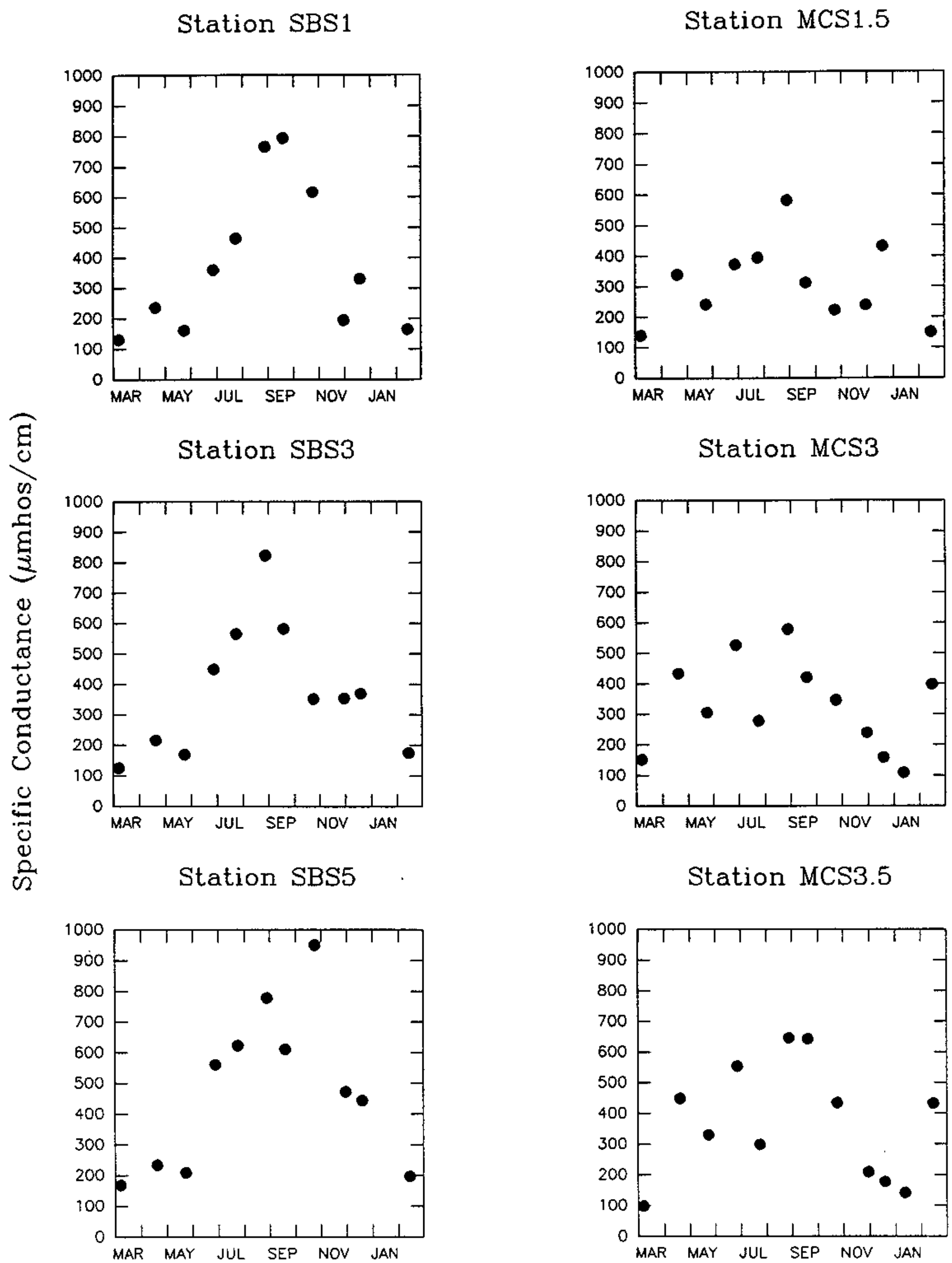


Figure 3. Temporal distribution of specific conductance (μmhos/cm). Steele Bayou stations on left, Main Canal stations on right (Continued)

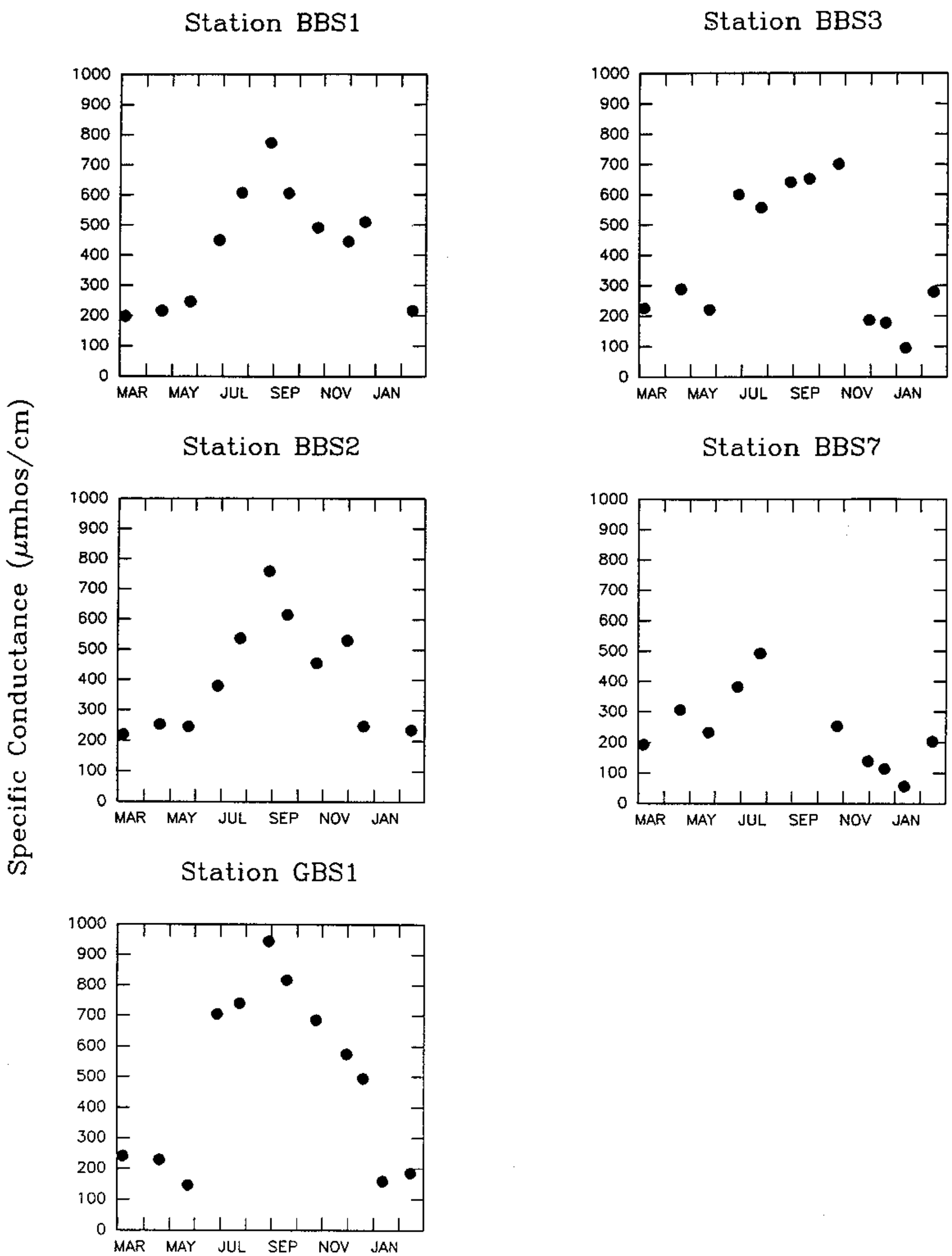


Figure 3. Black Bayou stations (Concluded)

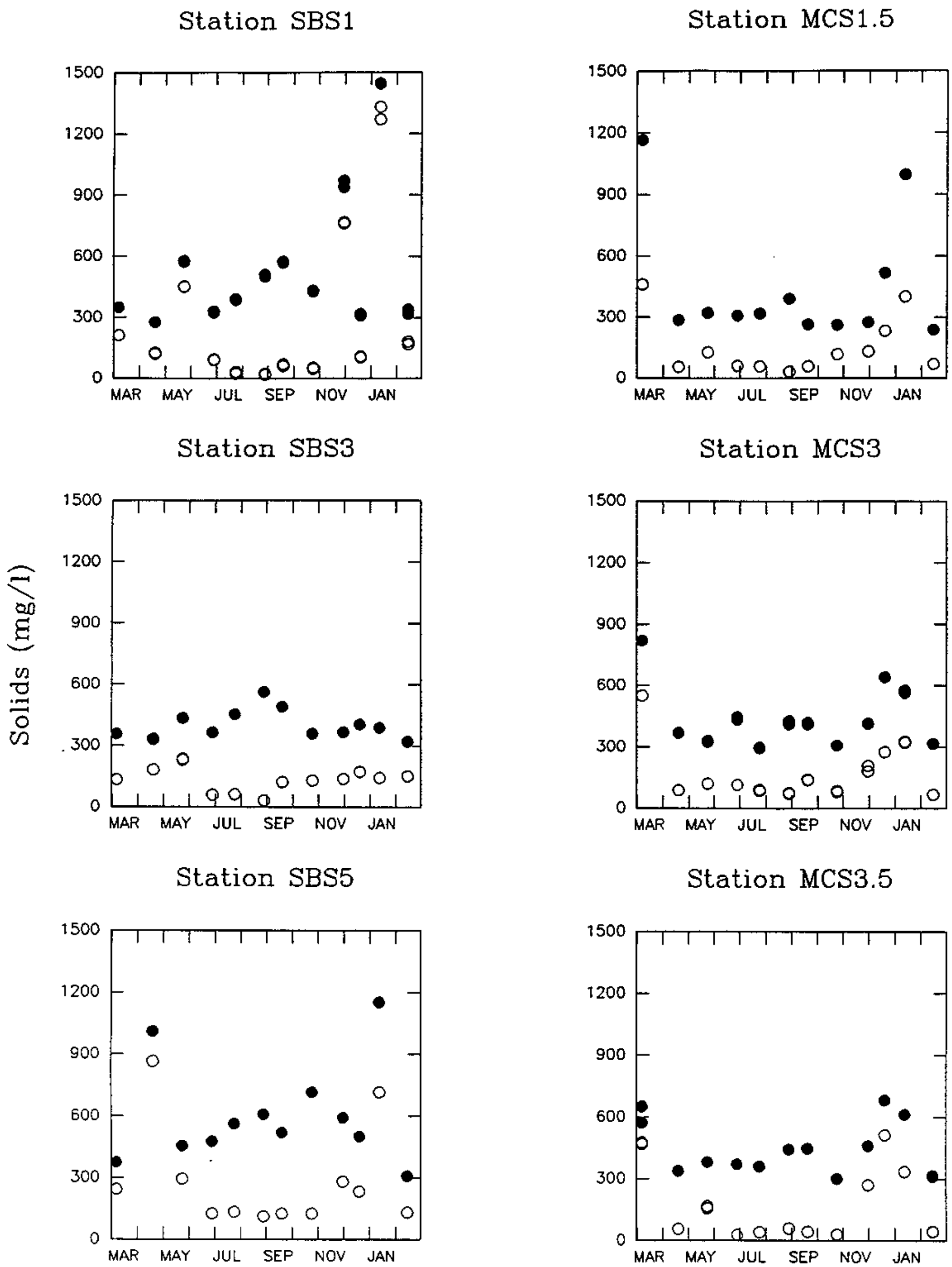


Figure 4. Temporal distribution of solids (mg/l). Solid circles depict total solids, and hollow circles depict suspended solids. Steele Bayou stations on left, Main Canal stations on right (Continued)

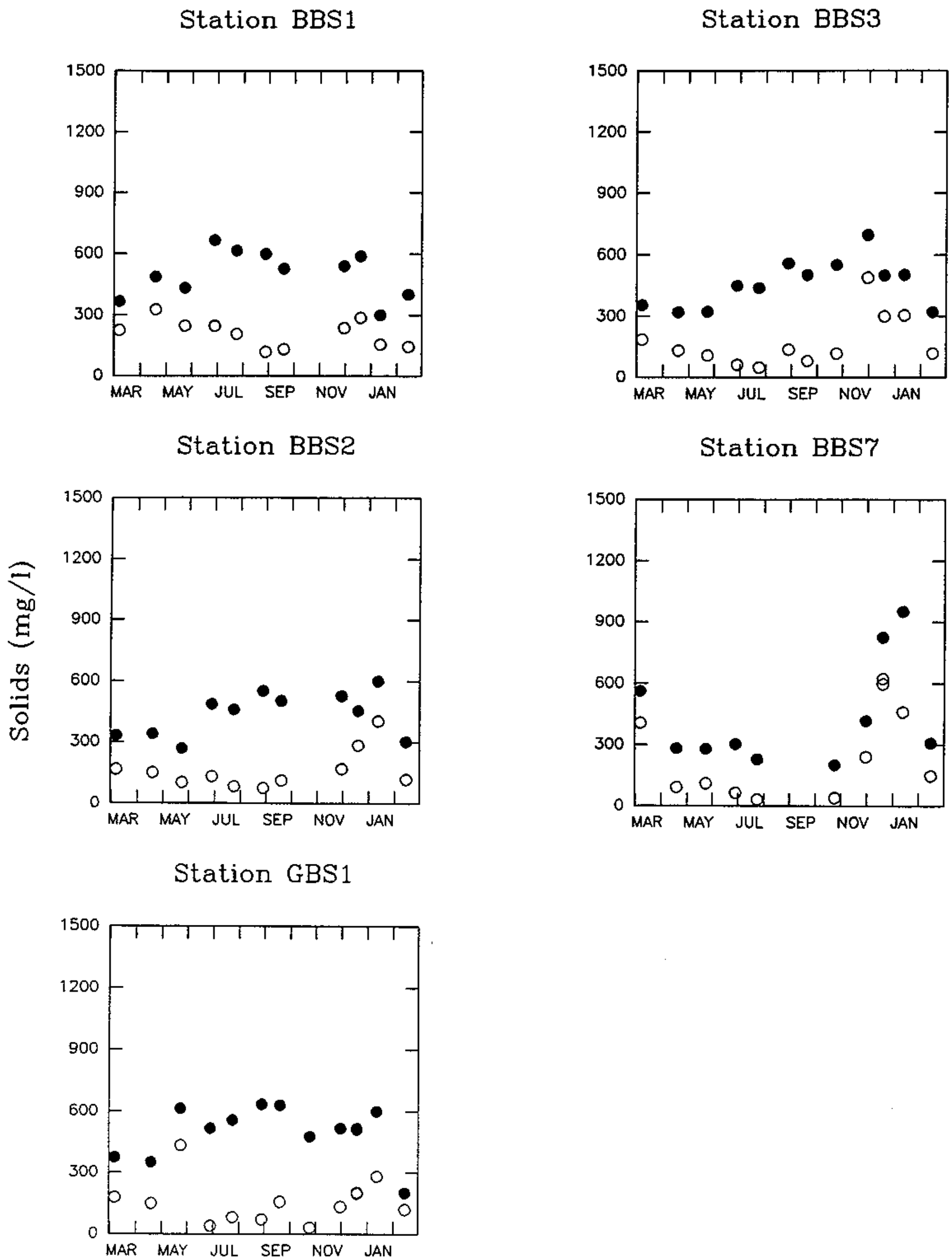


Figure 4. Black Bayou stations (Concluded)

Turbidity

Turbidity values were between 7 and 400 nephelometric turbidity units (NTUs) during the study period (Figure 5). The distribution of turbidity values was similar to that for suspended solids, with highest observed values occurring coincident with periods of high flow and runoff.

Nitrogen

Total organic nitrogen concentrations were generally between 1 and 4 mg/l, with values between 6 and 10 mg/l occurring at stations SBS5 (Black Bayou near Percy), MCS3 (Main Canal at Wayside), GBS1 (Granicus Bayou at Highway 12), and BBS3 (Black Bayou at Arcola) in July and October (Figure 6). The source of these elevated values was not readily apparent.

Nitrate/nitrite nitrogen concentrations were generally between 0.02 mg/l (detection limit) and 2.7 mg/l (Figure 7). Values above 2.0 mg/l were observed only at station SBS1 (Steele Bayou at Rolling Fork) in November and at stations BBS2 (Black Bayou at Estill) and BBS7 (Black Bayou at Leland) in July and May, respectively. Concentrations observed in the spring, late fall, and winter were relatively higher than concentrations observed during summer months.

Ammonia concentrations were generally between the detection limit (0.02 mg/l) and 0.6 mg/l (Figure 8). Values between 0.8 and 1.0 mg/l were observed at MCS1.5 (Granny Baker Bayou near James), MCS3 (Main Canal at Wayside), and GBS1 (Granicus Bayou at Highway 12) in July, September, and November.

Phosphorus

Total phosphorus concentrations ranged from 0.14 to 1.8 mg/l with most concentrations observed between 0.2 and 0.4 mg/l (Figure 9). Higher total phosphorus concentrations generally occurred coincident with periods of elevated flows. Total dissolved phosphorus concentrations were between 0.03 and 1.1 mg/l and were relatively constant (Figure 9, hollow circles). Total dissolved phosphorus concentrations greater than 0.04 mg/l were observed at stations SBS5 (Black Bayou near Percy), BBS3 (Black Bayou at Arcola), and MCS3.5 (Main Canal at Swiftwater).

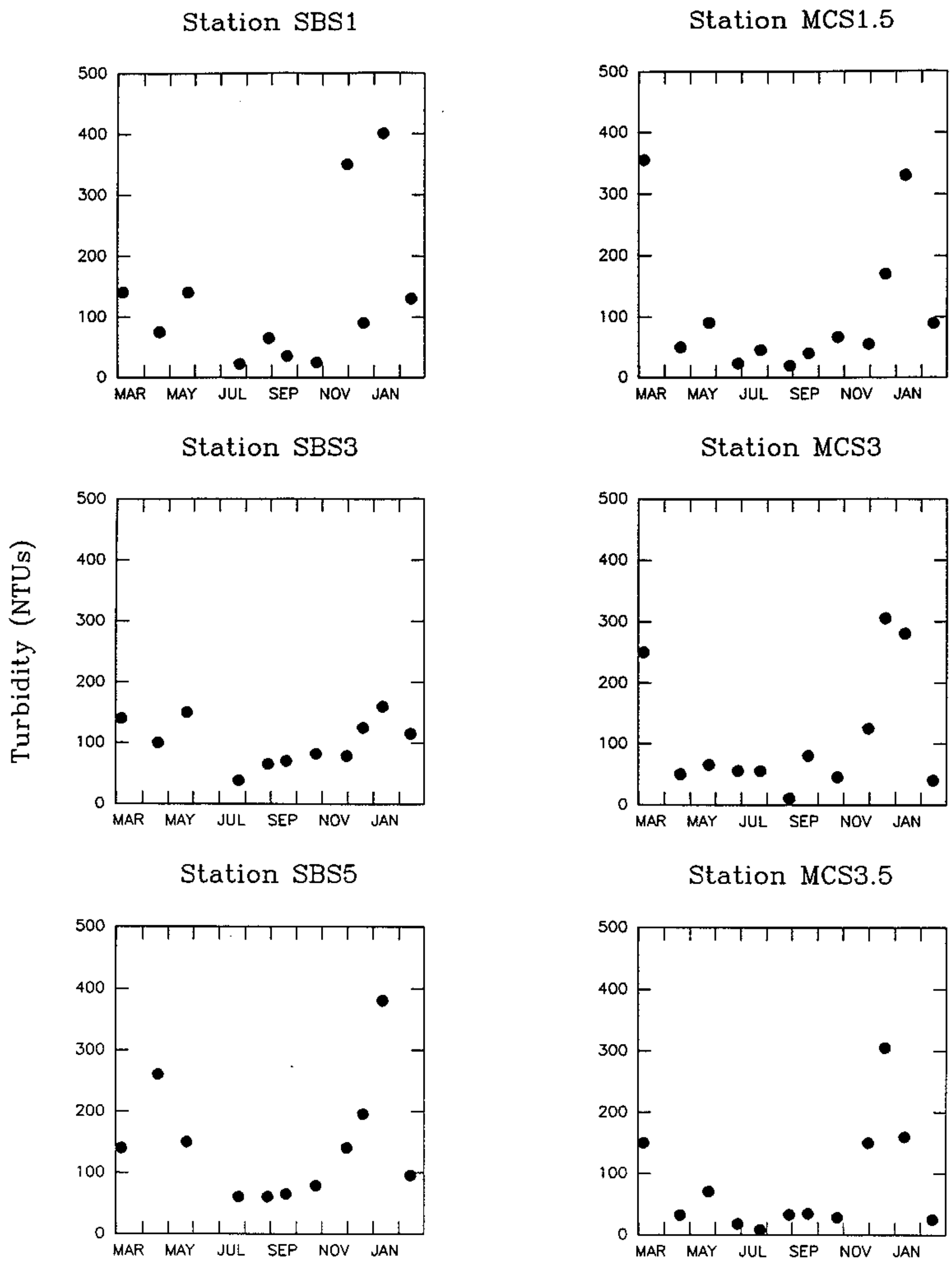


Figure 5. Temporal distribution of turbidity (NTUs). Steele Bayou stations on left, Main Canal stations on right (Continued)

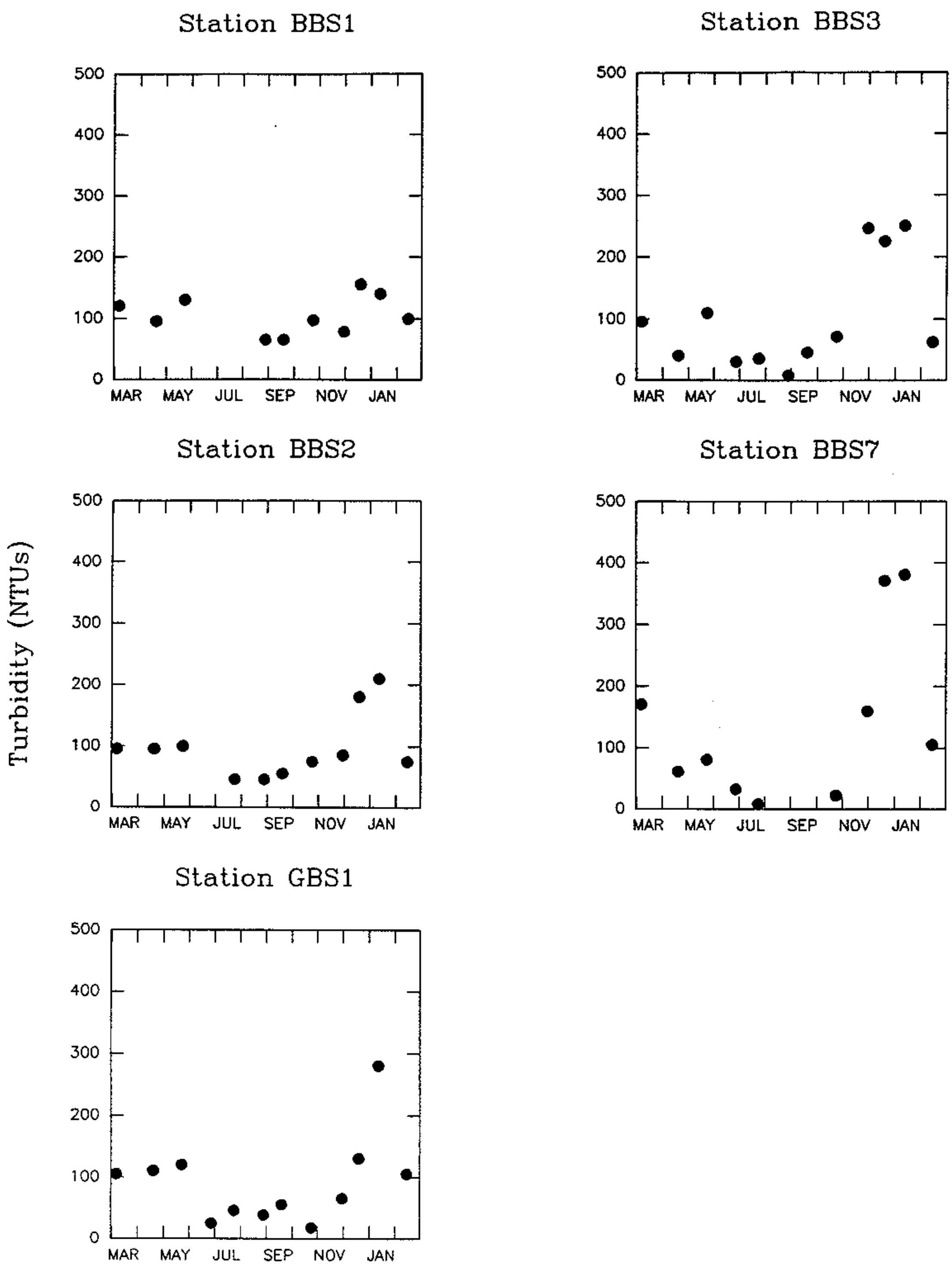


Figure 5. Black Bayou stations (Concluded)

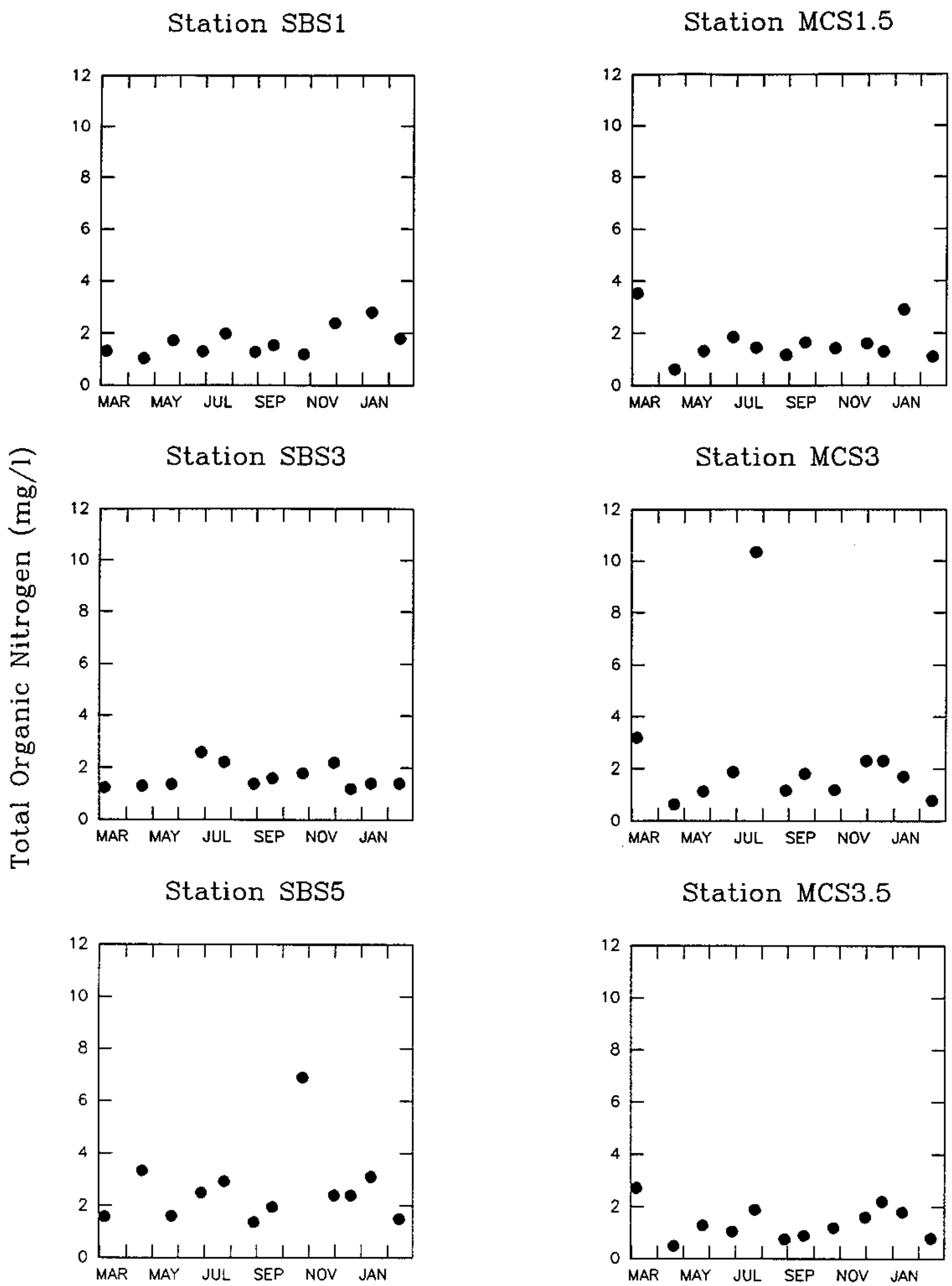


Figure 6. Temporal distribution of total organic nitrogen (mg/l). Steele Bayou stations on left, Main Canal stations on right (Continued)

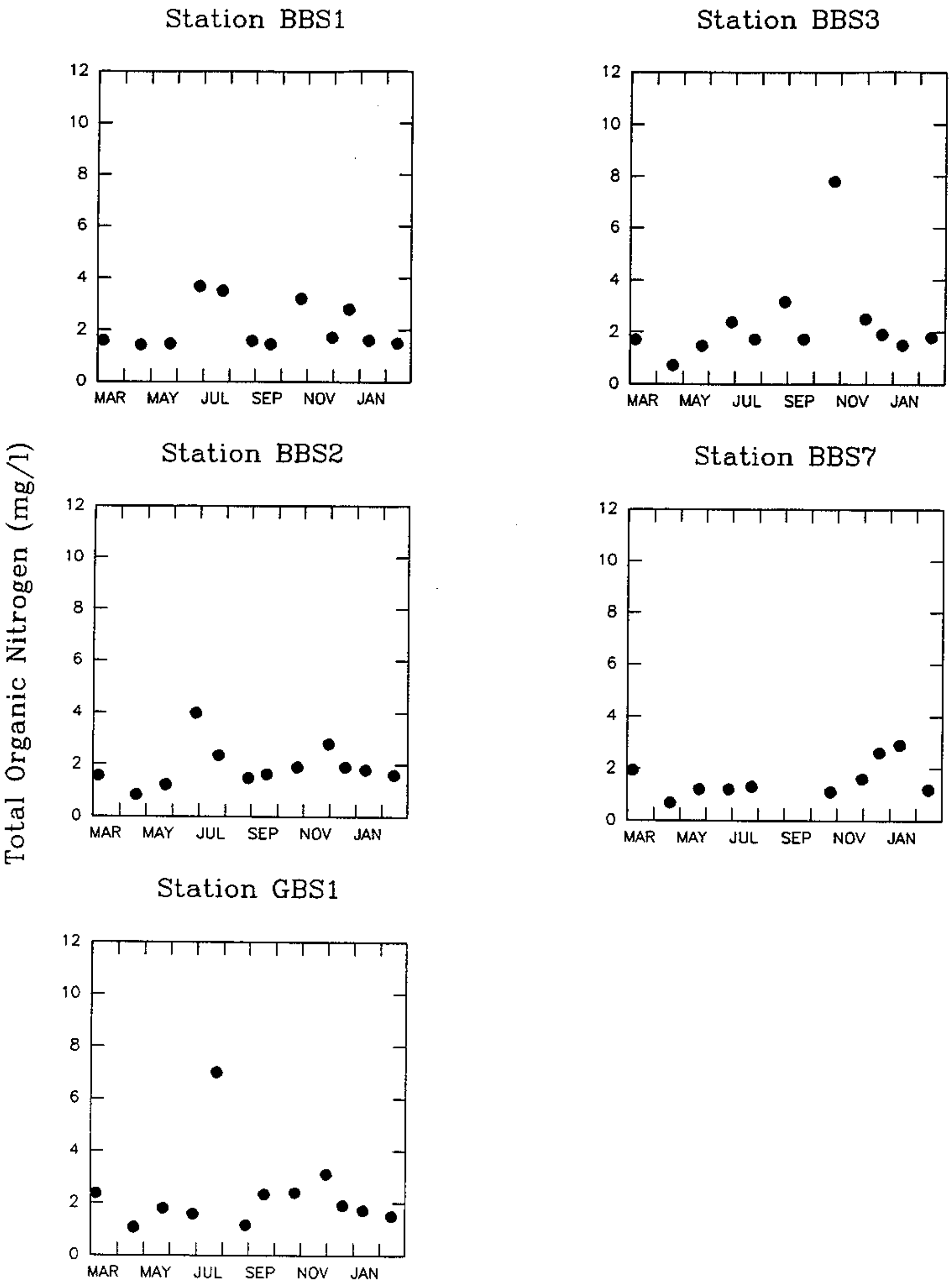


Figure 6. Black Bayou stations (Concluded)

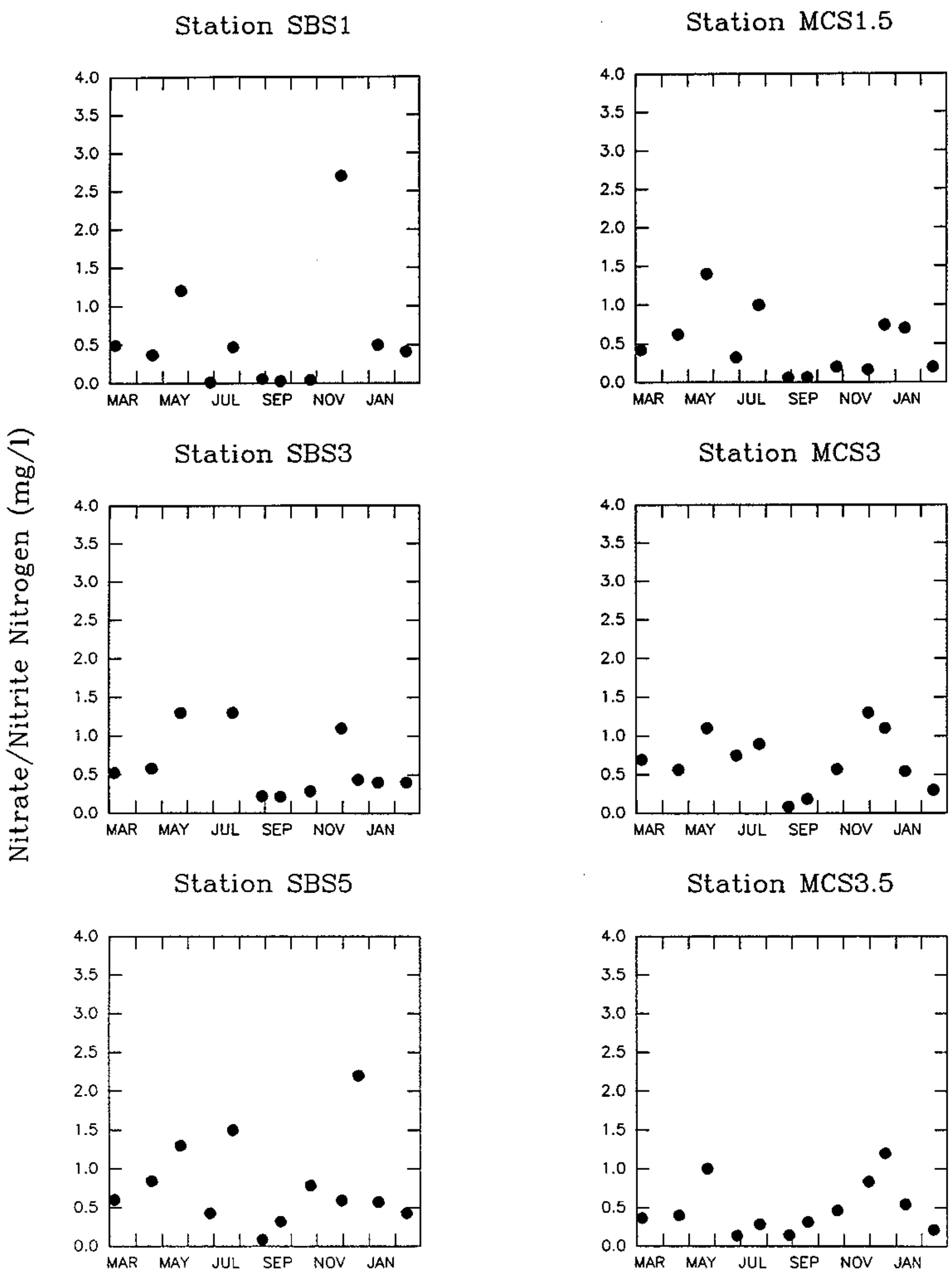


Figure 7. Temporal distribution of nitrate/nitrite nitrogen (mg/l). Steele Bayou stations on left, Main Canal stations on right (Continued)

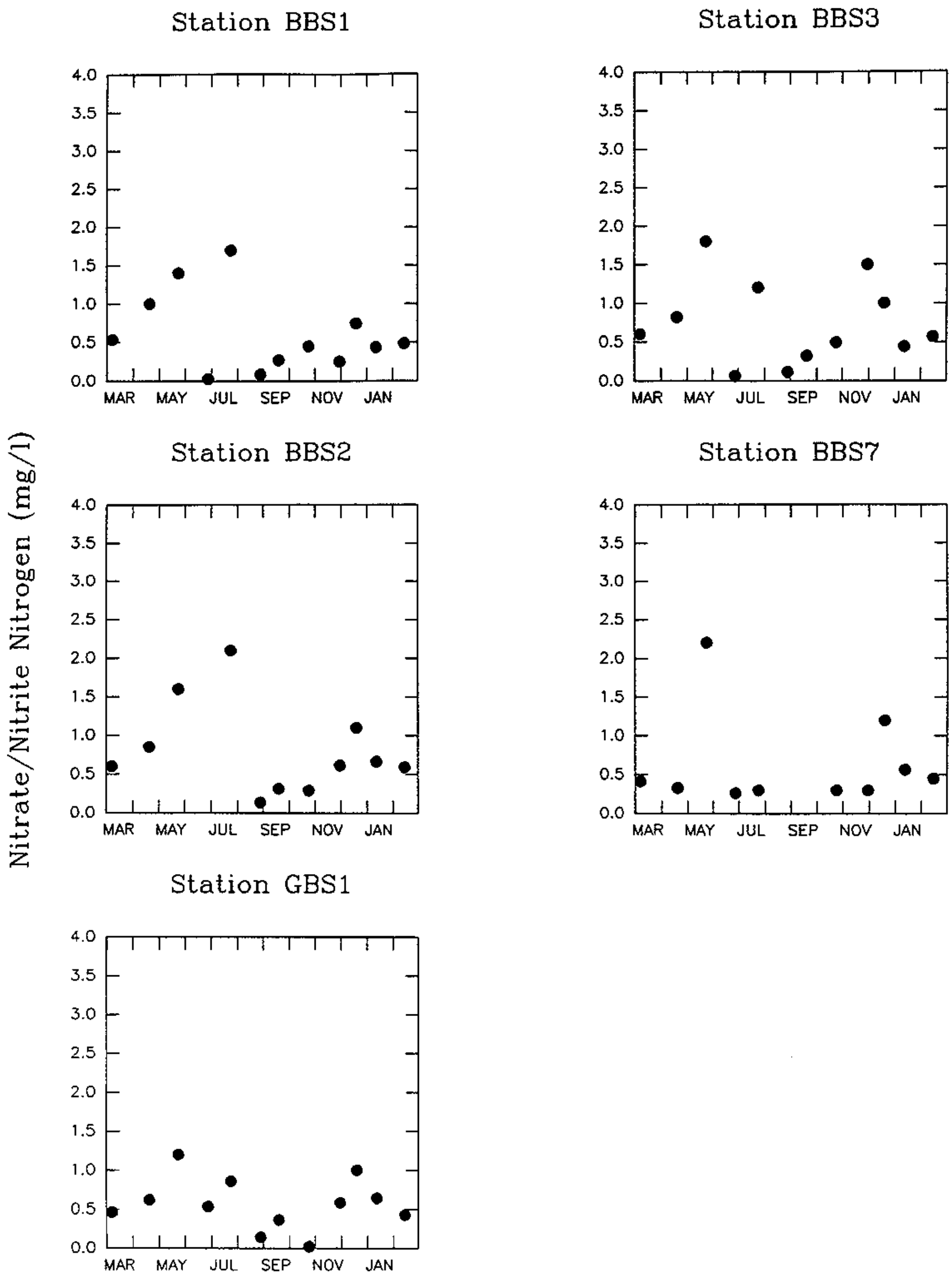


Figure 7. Black Bayou stations (Concluded)

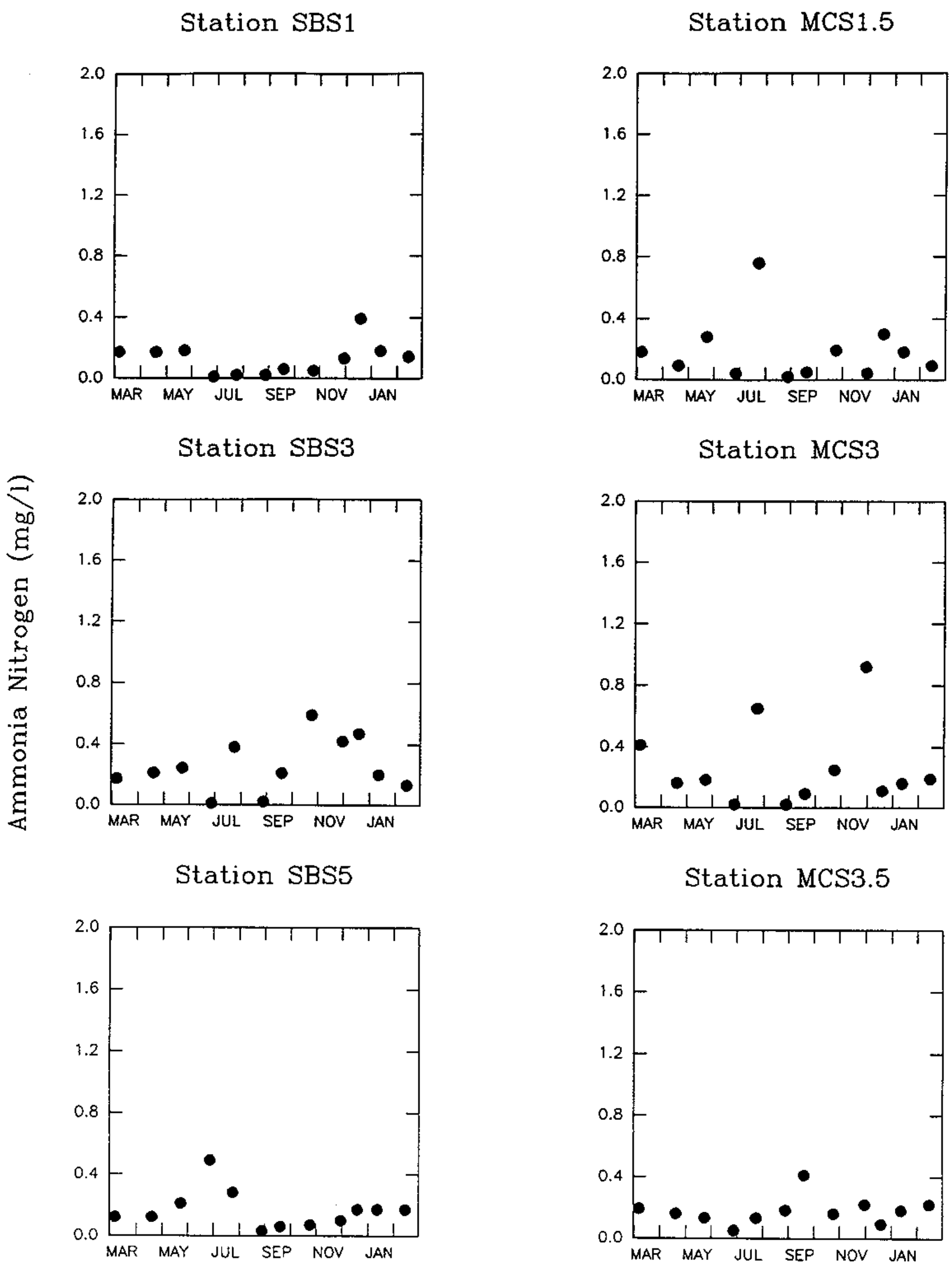


Figure 8. Temporal distribution of ammonia nitrogen (mg/l). Steele Bayou stations on left, Main Canal stations on right (Continued)

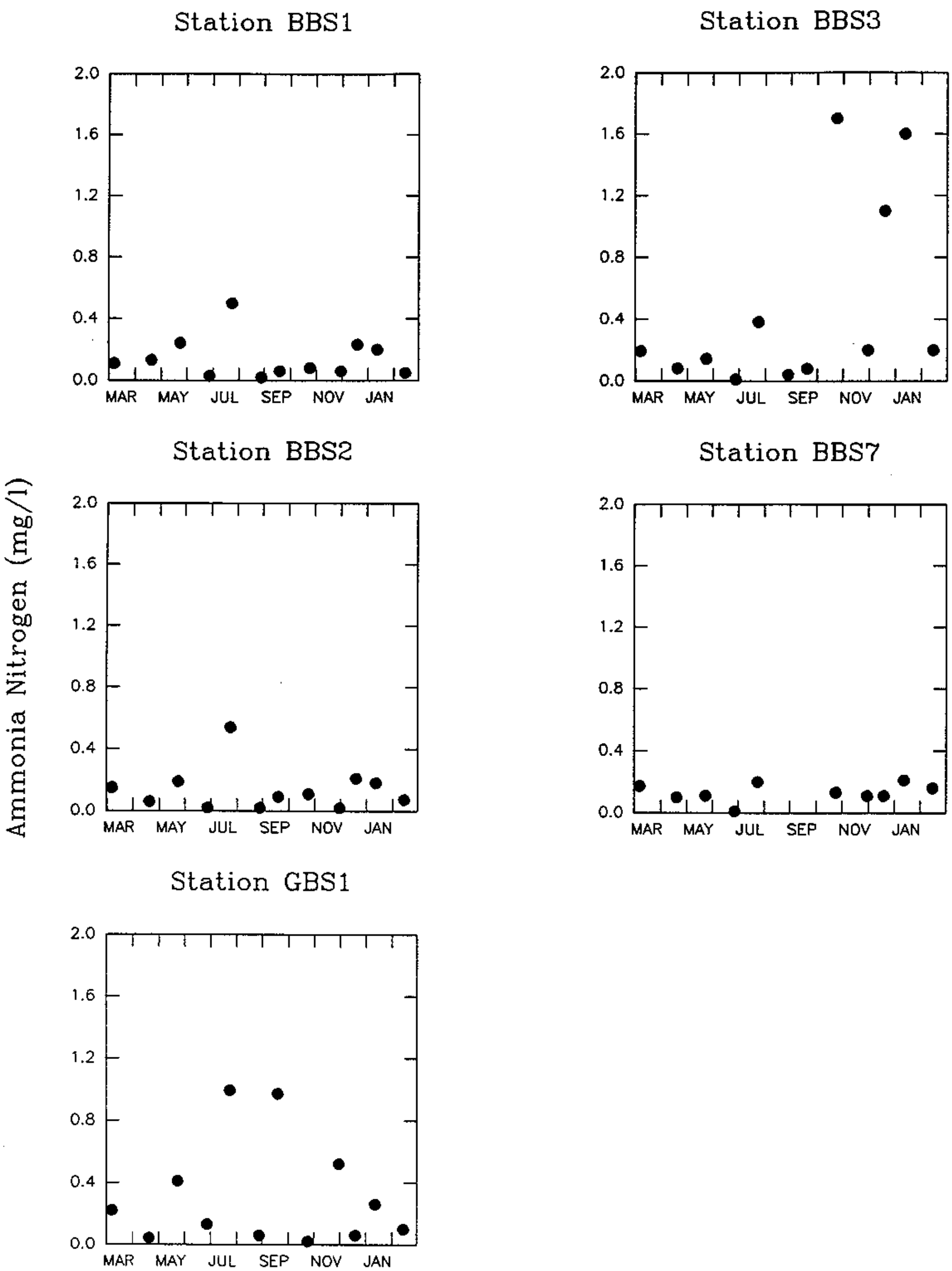


Figure 8. Black Bayou stations (Concluded)

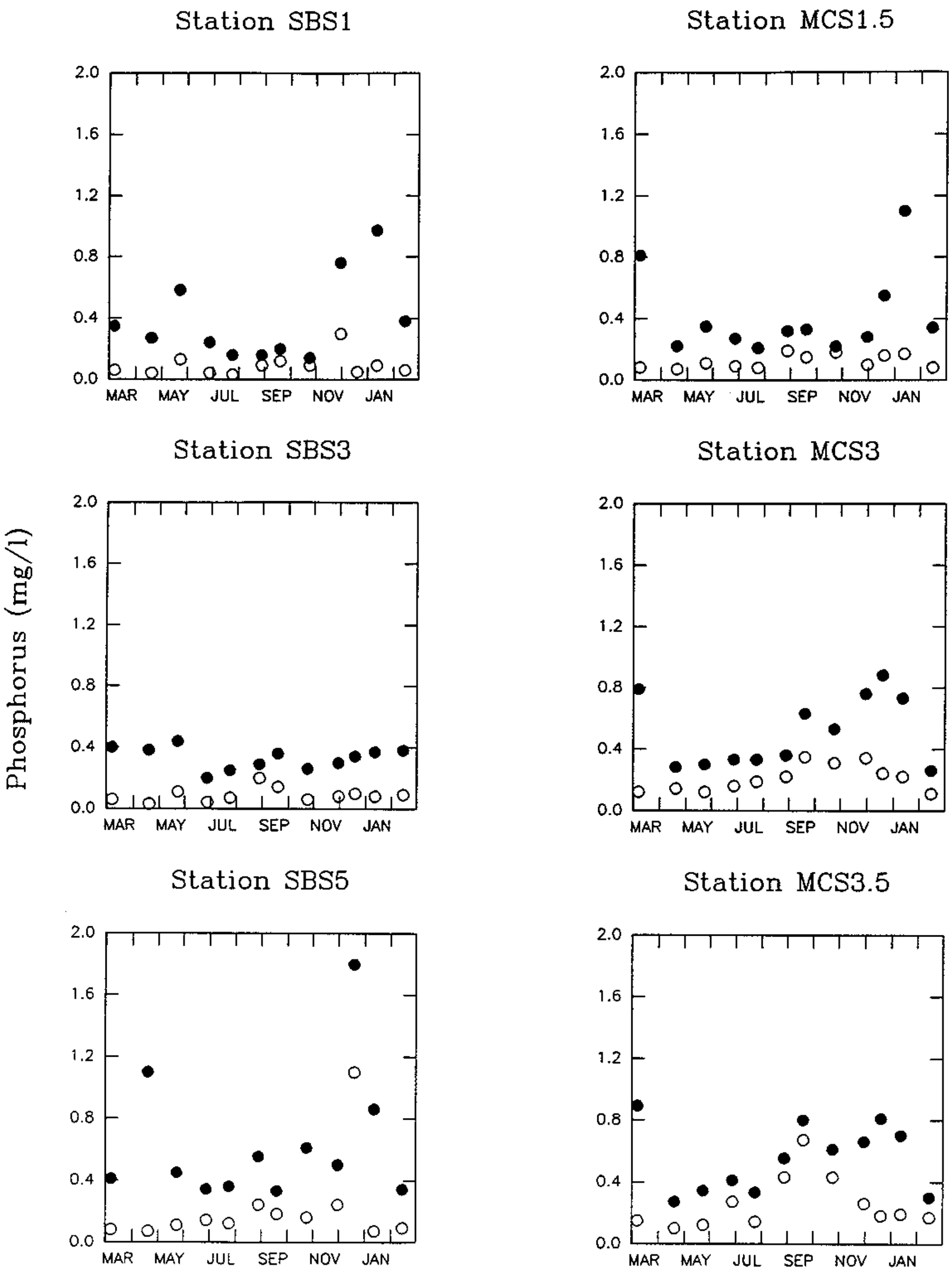


Figure 9. Temporal distribution of phosphorus (mg/l). Solid circles depict total phosphorus, and hollow circles depict total dissolved phosphorus, Steele Bayou stations on left, Main Canal stations on right (Continued)

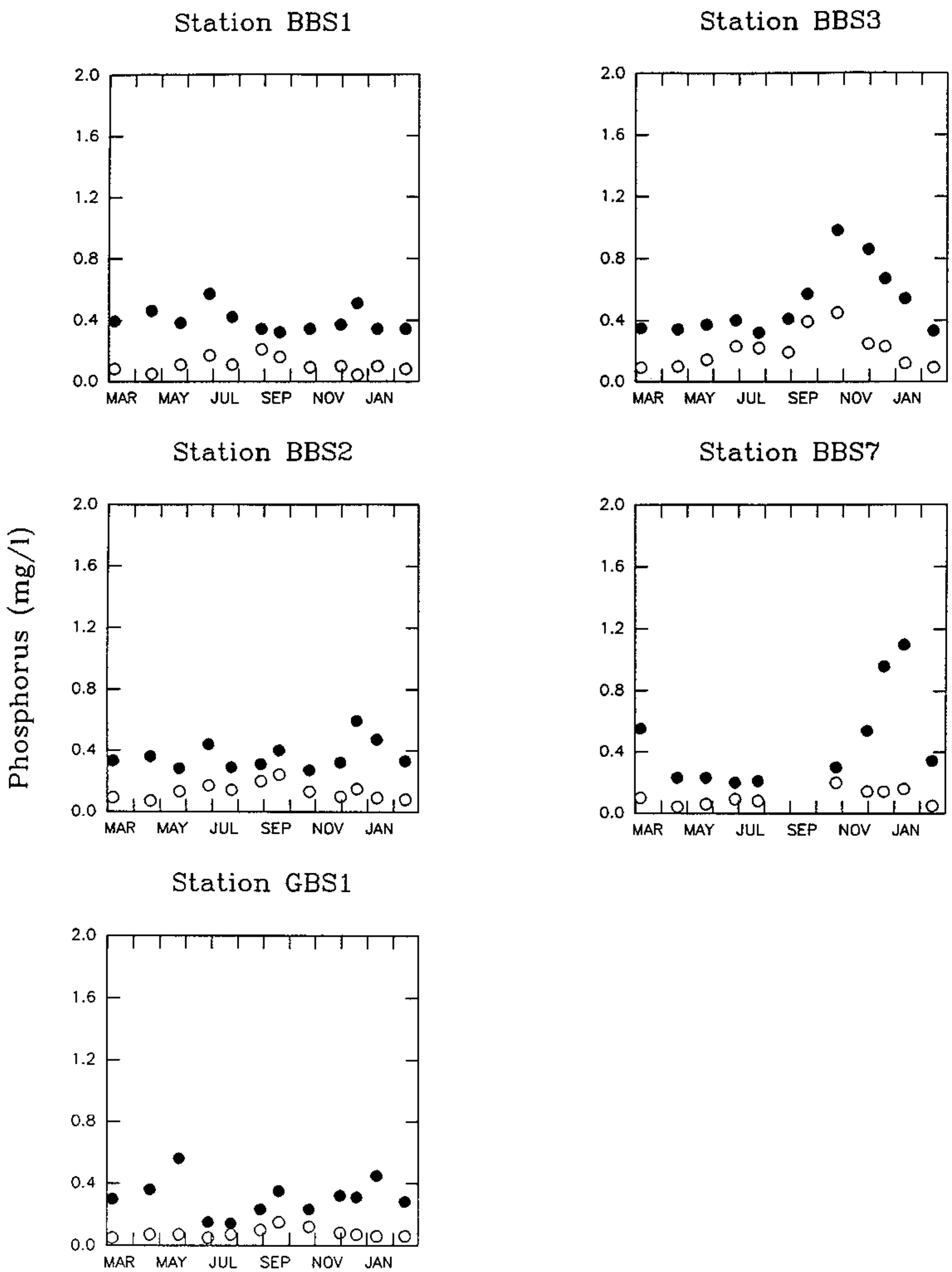


Figure 9. Black Bayou stations (Concluded)

Organic Carbon

Total organic carbon concentrations generally were between 4 and 8 mg/l and displayed a trend of increasing concentrations from March through December (Figure 10). Concentrations above 8 mg/l most often occurred September through December. Differences in spatial distribution were not readily apparent. Dissolved organic carbon comprised the majority of the total organic carbon and displayed similar concentration distribution patterns (Figure 10).

Chlorophyll *a*

Chlorophyll *a* concentrations displayed seasonal trends with relatively lower concentrations occurring December through May and higher concentrations occurring June through November (Figure 11). Values observed from December through May were between 5 and 20 μg/l. Chlorophyll *a* concentrations were more variable during June through November and exceeded 20 μg/l at nearly all stations at sometime during the summer growing season. Chlorophyll *a* concentrations above 40 μg/l were observed at stations SBS5 (Black Bayou near Percy), MCS1.5 (Granny Baker Bayou near James), BBS1 (Black Bayou at Highway 12), and BBS3 (Black Bayou at Arcola) coincident with field observations of noticeable algal populations.

Spatial Variability in Water Quality

Assessments of spatial variability in physicochemical characteristics within subwatersheds during June and January were based on mean values, standard deviations, and coefficients of variation (Table 5). The survey conducted in June followed the last high-flow event prior to the summer growing season, providing baseline conditions for the low-flow summer period. The survey conducted in January followed a period of high flow in December and was coincident with a single runoff event which preceded another period of prolonged high flow.

Evaluation of coefficients of variation in the June survey suggest that ammonia and nitrate/nitrite concentrations were highly variable (100-150 and 60-125%, respectively) in most of the subwatersheds. Variability of chlorophyll *a* concentrations was greater than 20% in all subwatersheds. With the exception of a few, coefficients of variation were relatively lower for the remainder of the variables. Concentration variability was greatest for most

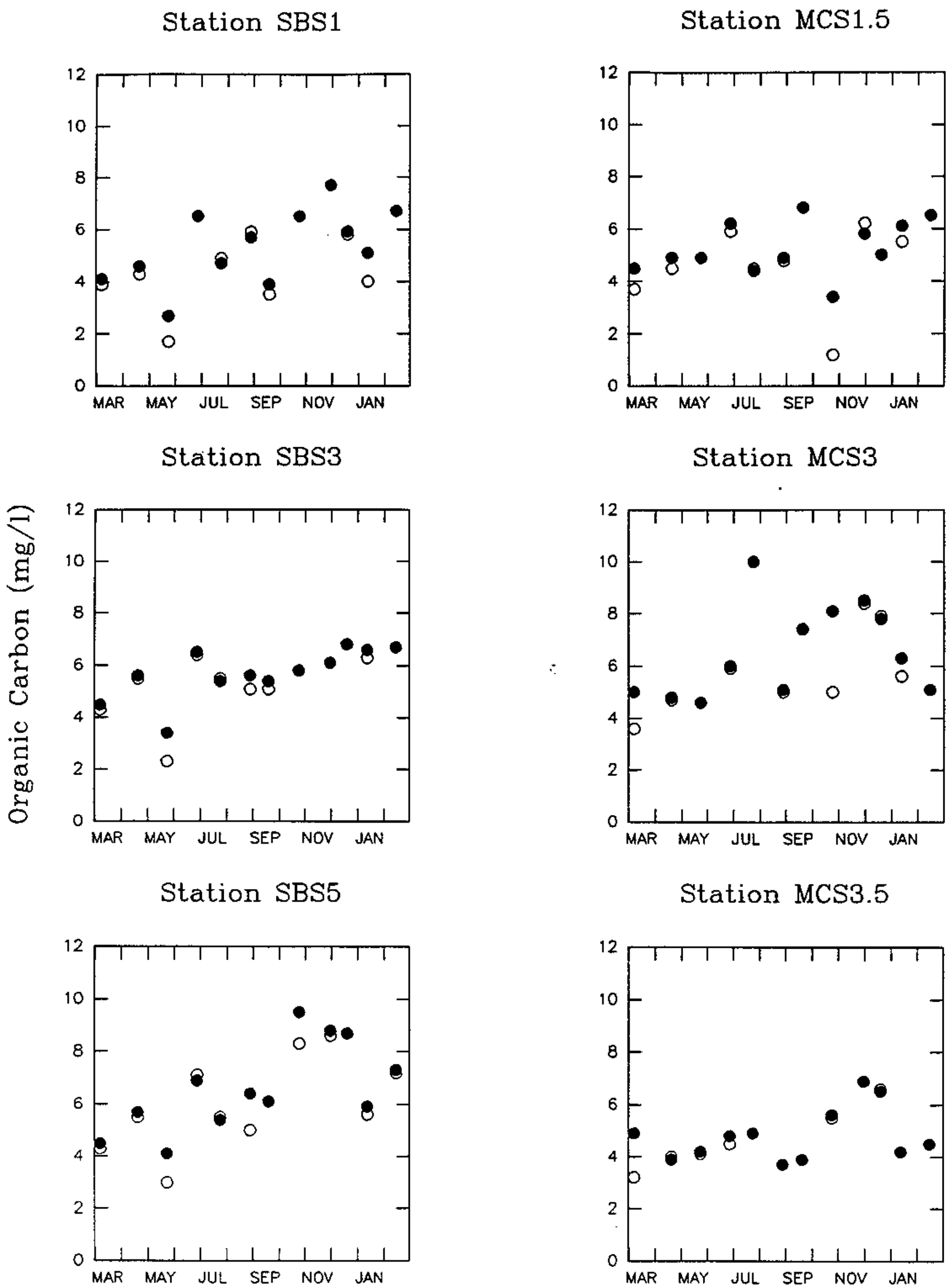
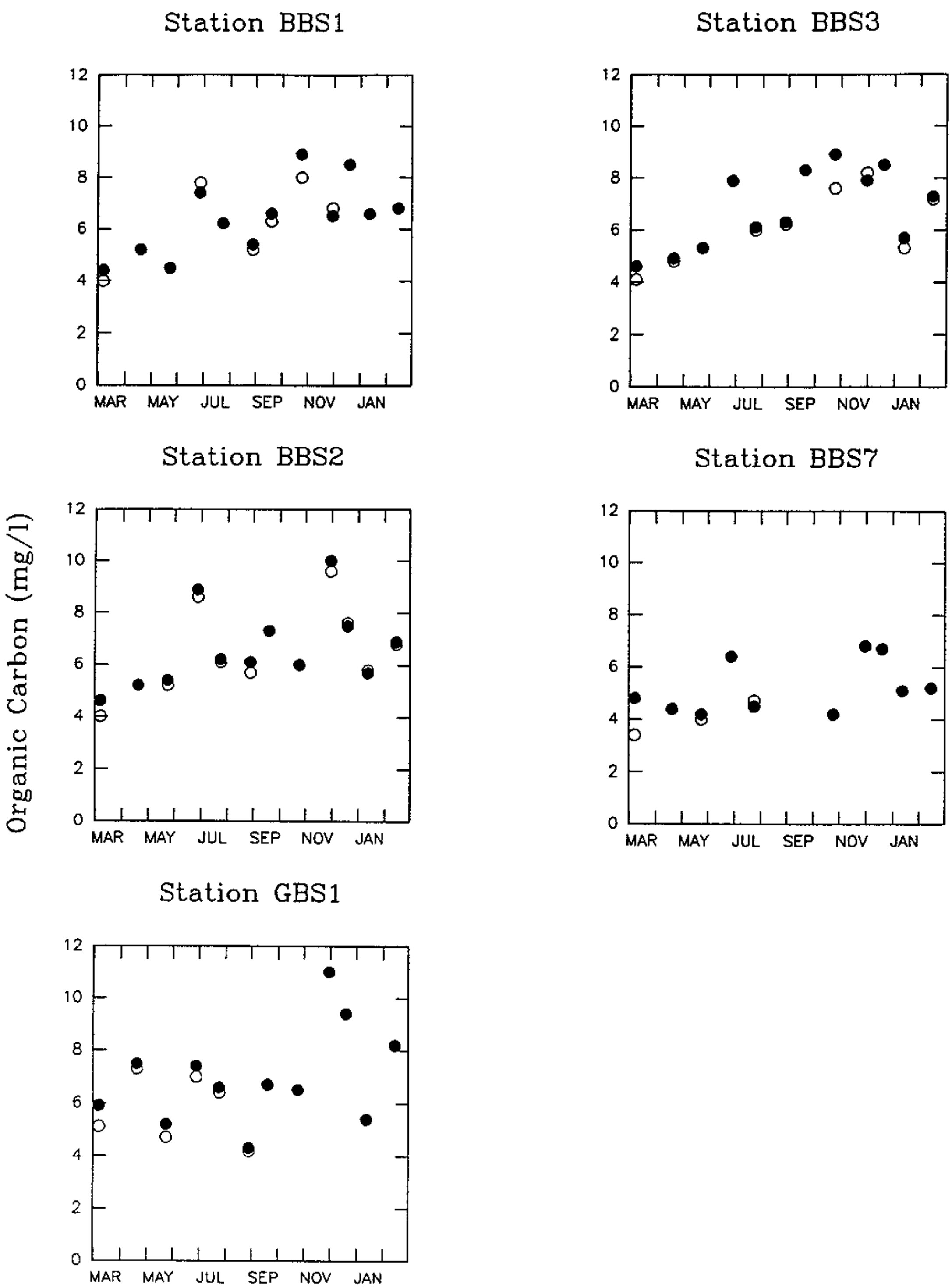


Figure 10. Temporal distribution of organic carbon (mg/l). Solid circles depict total organic carbon, and hollow circles depict dissolved organic carbon. Steele Bayou stations on left, Main Canal stations on right (Continued)



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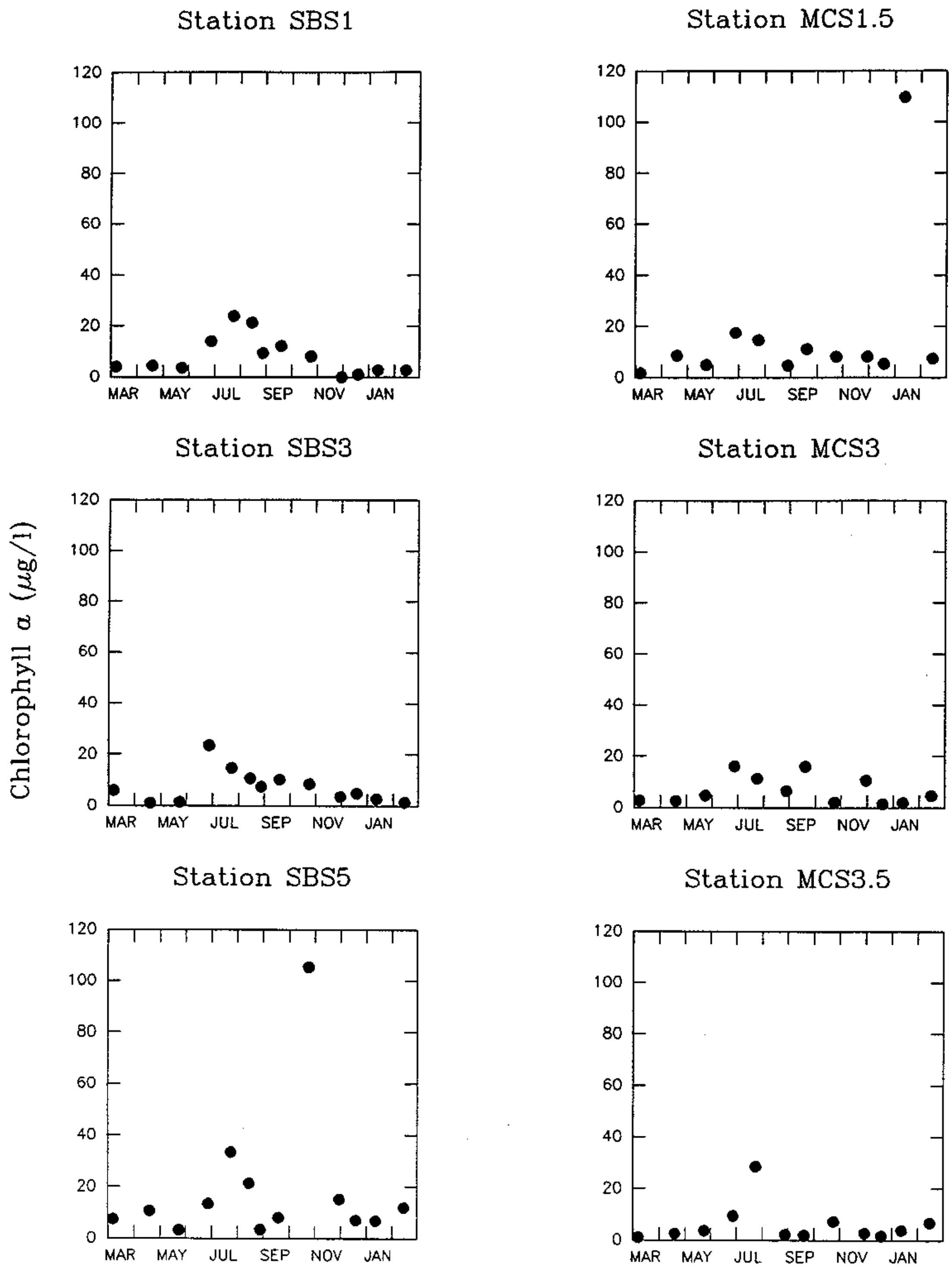

Figure 11. Temporal distribution of chlorophyll *a* (µg/l). Steele Bayou stations on left, Main Canal stations on right (Continued)

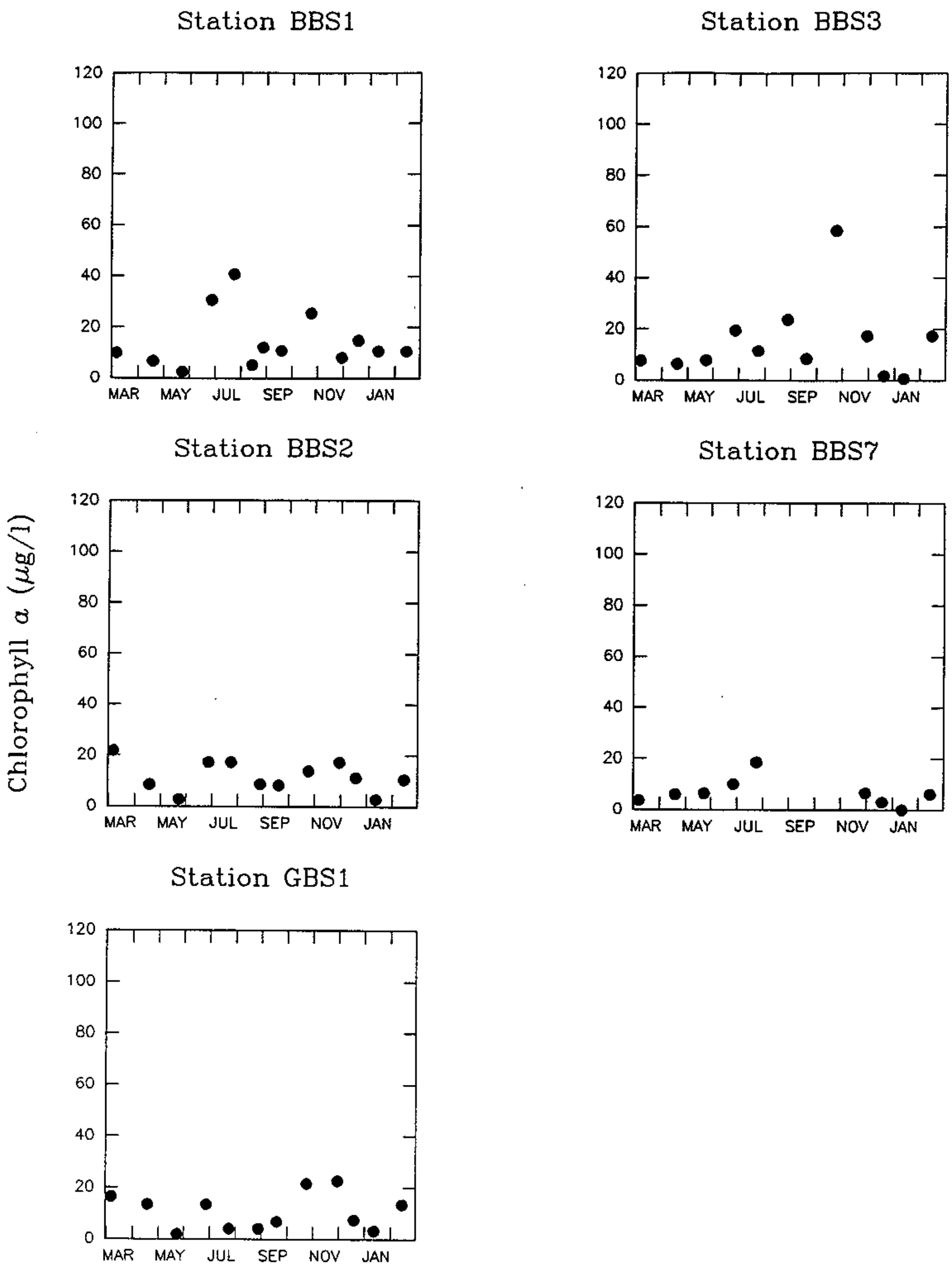

Figure 11. Black Bayou stations (Concluded)

variables (TS, TOC, DOC, NH_3-N, TP, TDP, and chlorophyll *a*) in subwatershed BB2, followed by subwatersheds MC2 and SB1.

In January, concentrations of most parameters were less variable than in June. However, total solids and total suspended solids concentrations were more variable in January than in June. Increased variability in January may be attributed to high flow and increased material transport. High variability of chlorophyll *a* in the MC1 subwatershed may be attributed to elevated concentrations at station MCS1.5 (Granny Baker Bayou near James).

Comparisons among subwatersheds, sampled during June, suggest that maximum mean values occur most often in subwatershed BB1 followed by subwatershed SB1 (Table 6 and Figure 12). Mean values of total solids and total suspended solids were significantly higher ($p < 0.05$) in subwatershed BB1. For total organic nitrogen, chlorophyll *a*, and total and dissolved organic carbon, the general trend was of higher concentrations in each downstream subwatershed (SB1, BB1, and MC1). Mean concentrations of turbidity, nitrate/nitrite nitrogen, ammonia nitrogen, total phosphorus, and total dissolved phosphorus were not significantly different between subwatersheds ($p > 0.05$) during June.

In January, nitrate/nitrite nitrogen, total phosphorus, and total dissolved phosphorus concentrations were generally higher in the upstream subwatersheds (MC1 and BB3) and significantly different ($p < 0.05$) from subwatersheds SB1 and BB1 (Table 7 and Figure 13). Mean concentrations of total solids, total suspended solids, turbidity, total organic nitrogen, ammonia nitrogen, and chlorophyll *a* were not significantly different among subwatersheds (Table 7).

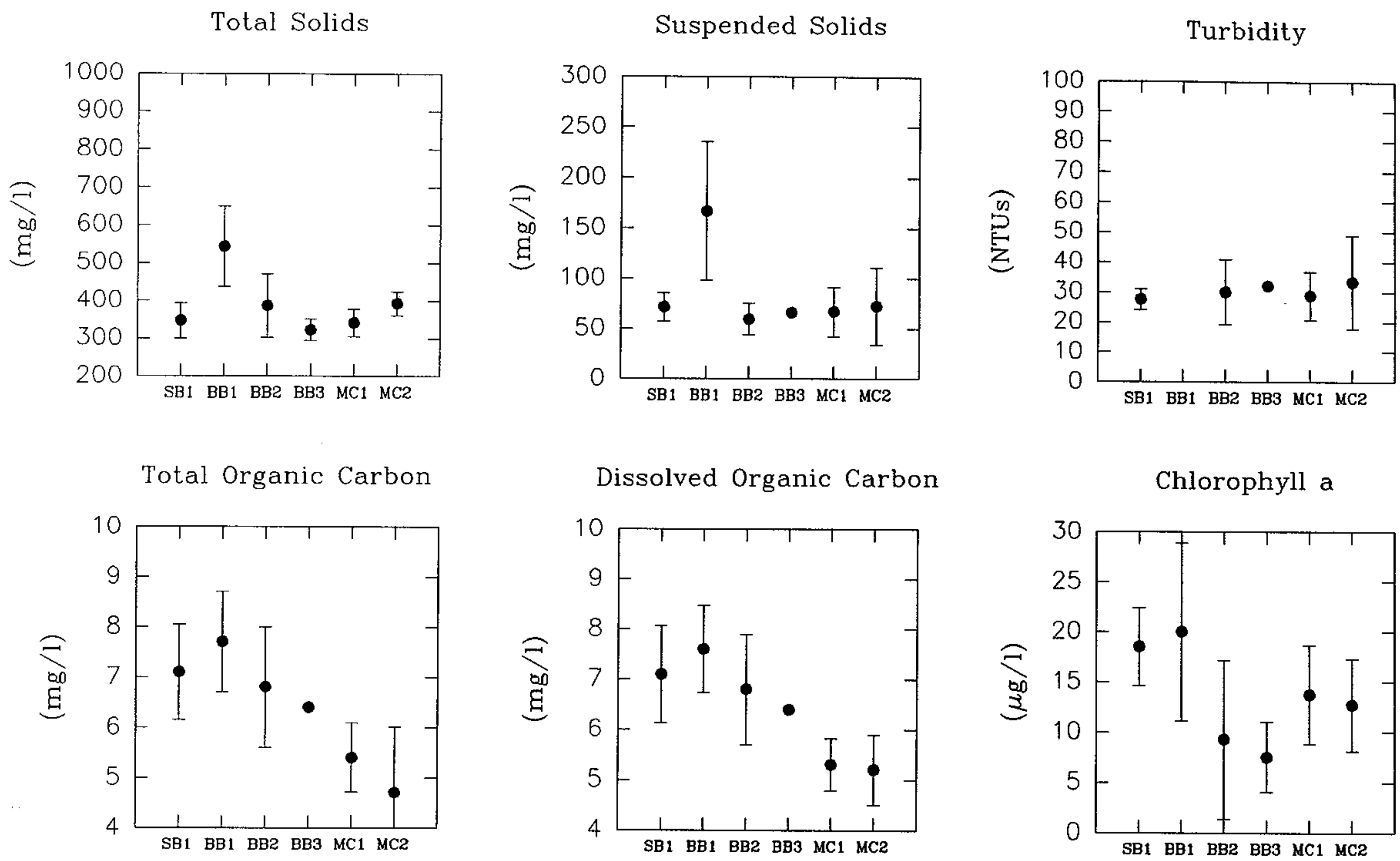

Figure 12. Spatial variability of selected parameters within subwatersheds for June 1990. Error bars represent one standard deviation (Continued)

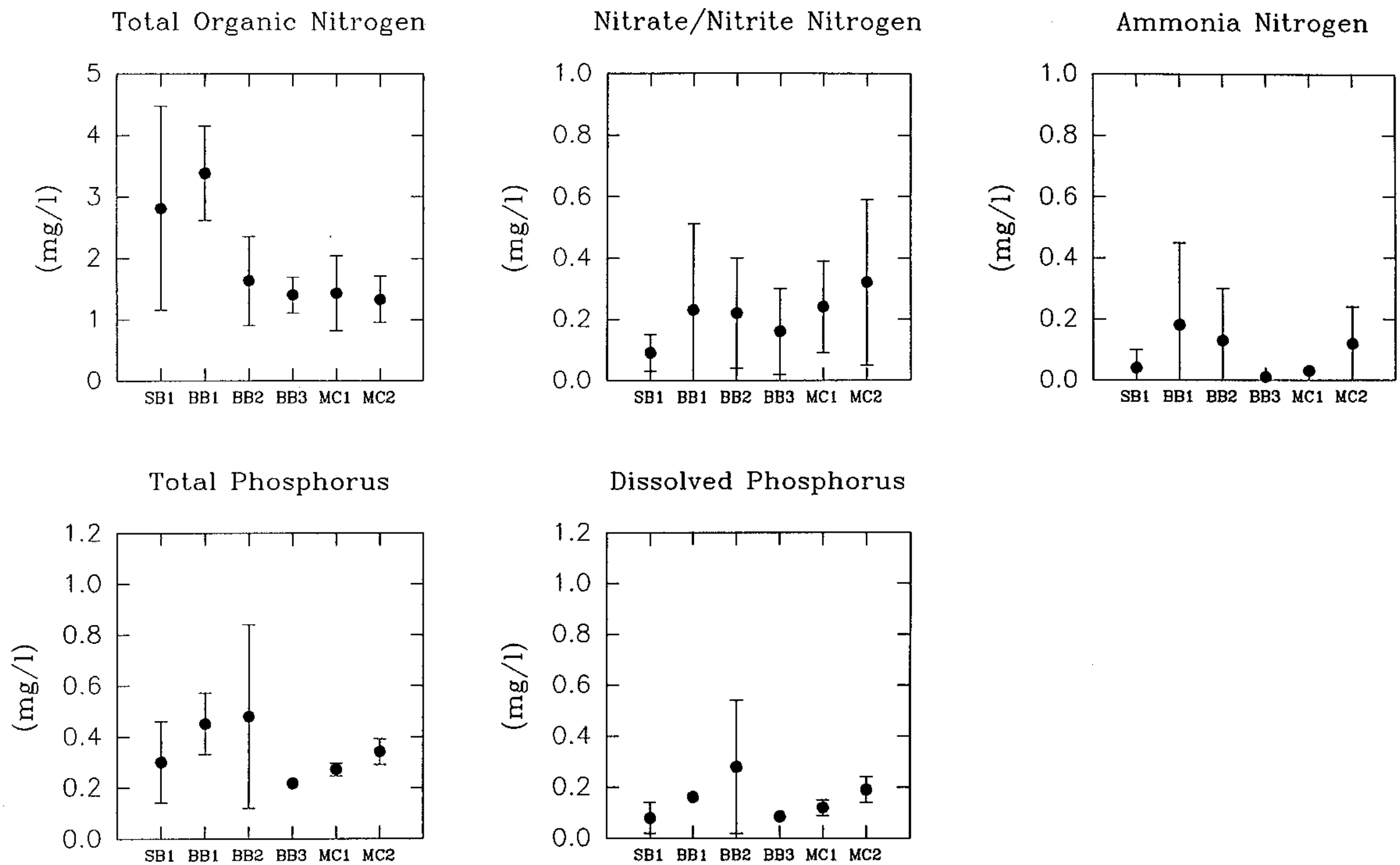

Figure 12. (Concluded)

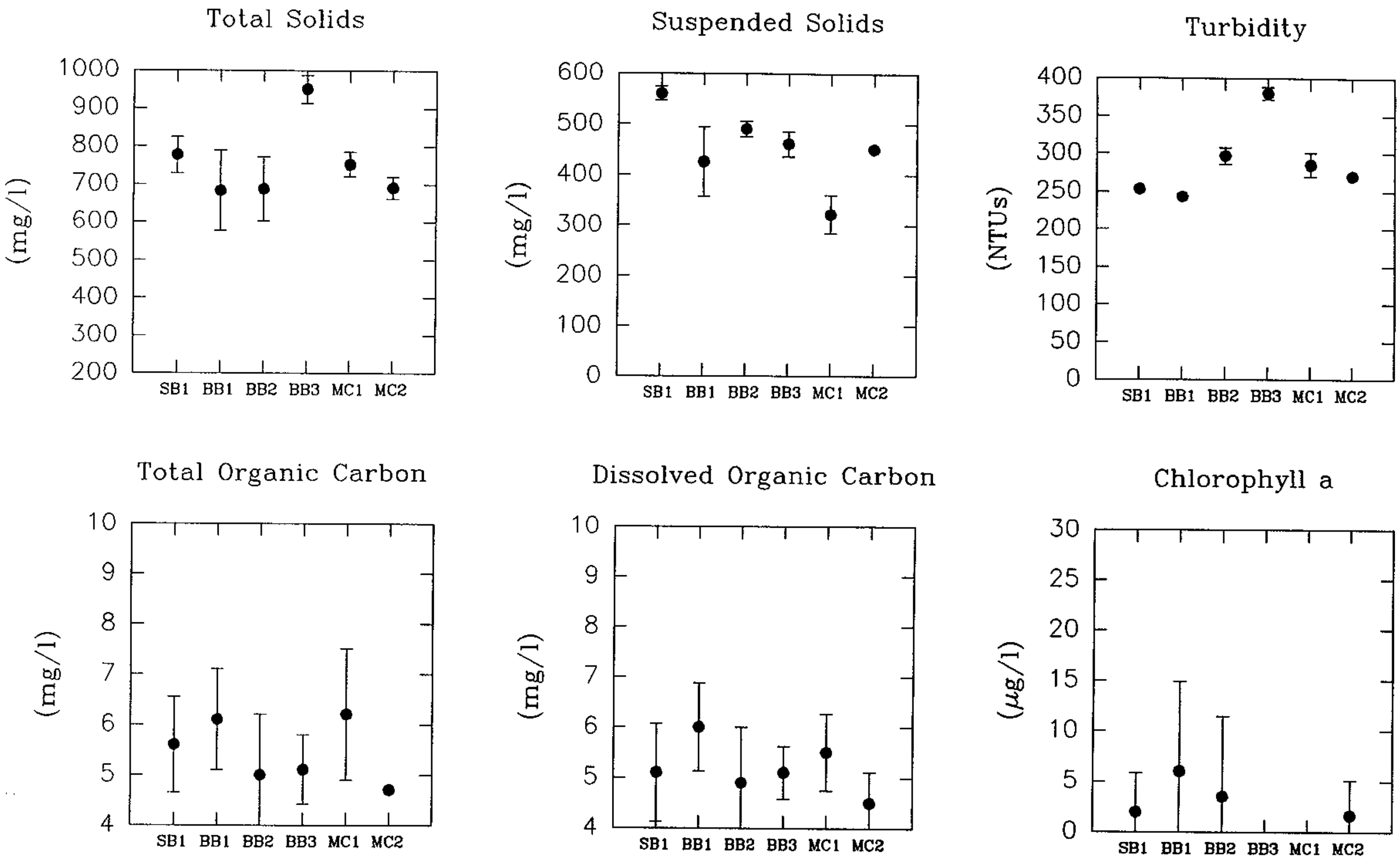

Figure 13. Spatial variability of selected parameters within subwatersheds for January 1991. Error bars represent one standard deviation (Continued)

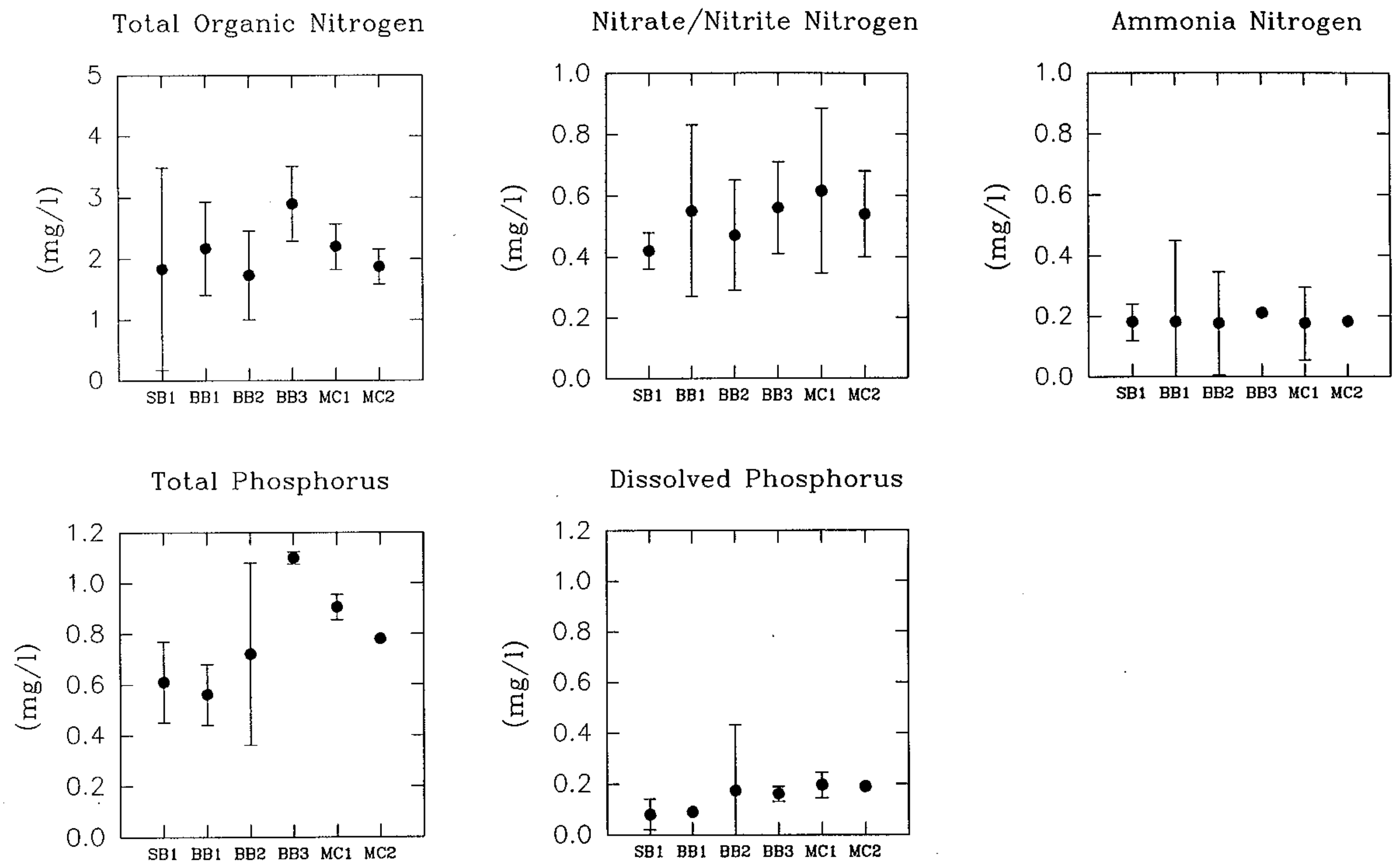

Figure 13. (Concluded)

Supplemental Water Quality Studies

Assessment of canopy-covered and open reaches

Differences between canopied (station BBS1, Black Bayou at Highway 12) and open reaches (station SBS1, Steele Bayou at Rolling Fork, and station BBS2, Black Bayou at Estill) were apparent in evaluations of the phytoplankton community. Rates of net and gross photosynthesis were similar at stations in open reaches and considerably higher than rates at the station in the canopied reach (Table 8). Dissimilarly, respiration rates decreased in a downstream direction. Daily gross productivity was higher in the open reaches, stations SBS1 (Steele Bayou at Rolling Fork) and BBS2 (Black Bayou at Estill), than in the canopied reach, station BBS1 (Black Bayou at Highway 12). Conversely, chlorophyll *a* values at station BBS1 were approximately twice those at stations SBS1 and BBS2 (Table 9). Blue green algal species (e.g. *Cyclotella*, *Oscillatoria*, and *Microcystis*) were dominant at the time of the study (Table 10).

Specific conductance, total solids, suspended solids, and total phosphorus were higher at BBS1 (Black Bayou at Highway 12) than at SBS1 (Steele Bayou at Rolling Fork) and BBS2 (Black Bayou at Estill) (Table 9). Total dissolved phosphorus was relatively lower at SBS1 (Steele Bayou at Rolling Fork). Total organic carbon and total nitrogen concentrations decreased from BBS2 (Black Bayou at Estill) to SBS1 (Steele Bayou at Rolling Fork).

Assessment of diel variation of in situ parameters

Diel variations in temperature and dissolved oxygen were apparent at all stations in the downstream region of the study area (Figure 14). Temperature maxima occurred in late afternoons and were between 28 and 30 °C with highest values occurring at SBS1 (Steele Bayou at Rolling Fork). Temperature decreases by approximately 2 °C were observed in early mornings.

Dissolved oxygen maxima and minima concentrations occurred in late afternoons and early mornings, respectively. While maximum concentrations were between 7 and 9 mg/l at SBS3 (Steele Bayou at Hampton), SBS5 (Black Bayou near Percy), and BBS1 (Black Bayou at Highway 12), highest concentrations occurred at SBS1 (Steele Bayou at Rolling Fork) (>10 mg/l). Minimum values remained above 3.5 mg/l at all stations.

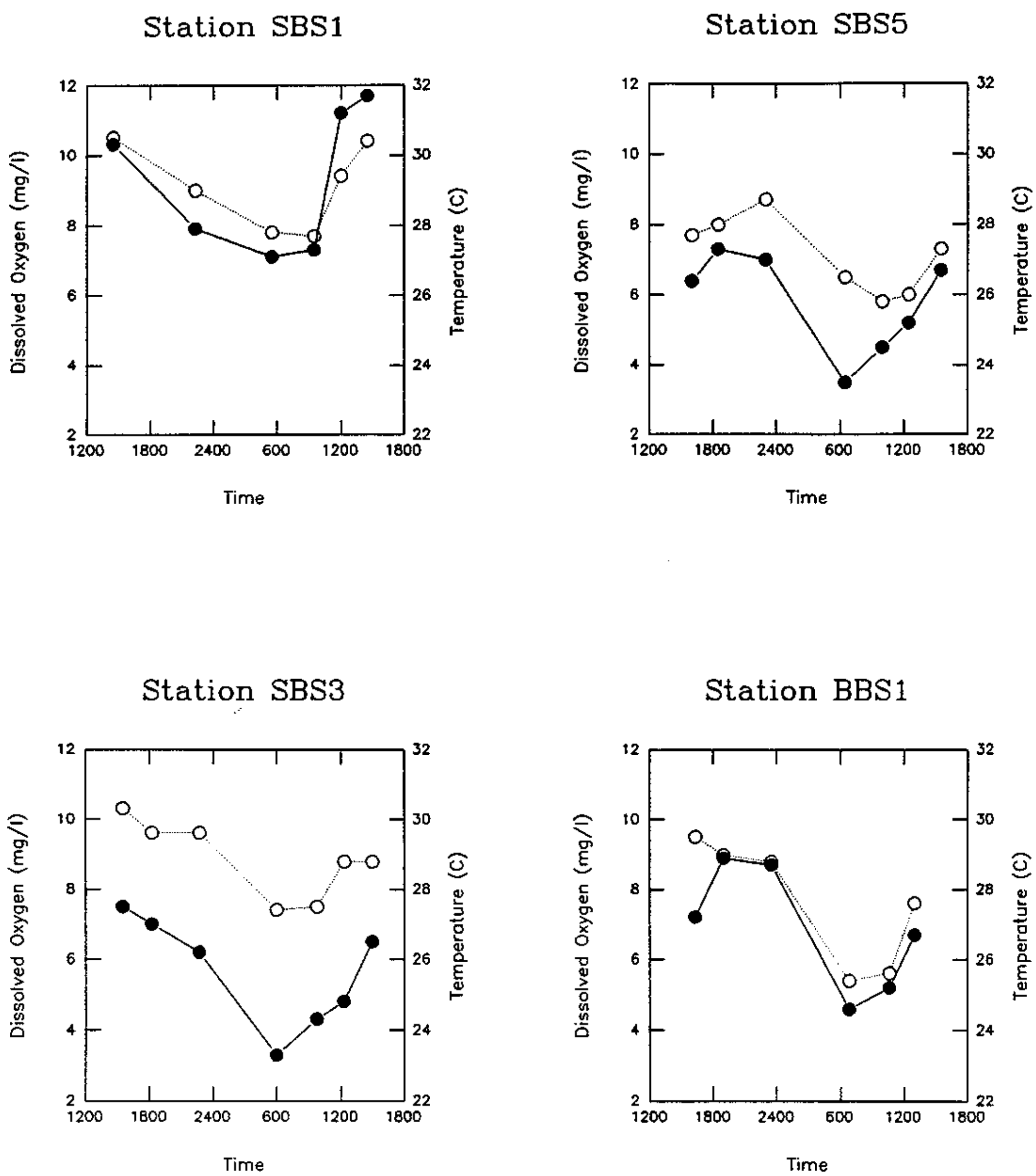

Figure 14. Diel changes in temperature (dashed line) and dissolved oxygen (solid line) in the downstream region of Steele Bayou, 13-14 August 1990

Insecticide and Herbicide Distribution

Values for most insecticide and all herbicide parameters were below detection limits for surface water samples collected in April, July, and October. Insecticides and herbicides occurring above detection limits were G-BHC, D-BHC, PPDDE, PPDDT, HPTCL, Dieldrin, Endrin, Diazinon, Malathion, and 2,4,5-T (Table 11). In April, insecticides were detected only in Black Bayou and downstream from Swan Lake in Steele Bayou. Insecticides and herbicides were detected primarily in Main Canal in July and October.

The most frequently detected pesticides in the surface sediments were PPDDT and its metabolites, and HPTCL, ENDOSU, and ENDALD (Table 12). Other pesticides, such as ENDOI, ENDOII, Endrin, and HEPTCLE were detected sporadically throughout the watershed. The values observed for PPDDT ranged from below detection limits at several sites to 0.0780 mg/kg at stations BBS7 (Black Bayou at Leland) and MCS3 (Main Canal at Wayside). Concentrations of PPDDE and PPDDD were above detection limits at almost all sites, and were generally higher than was PPDDT. The highest concentrations of PPDDE and PPDDD were 0.081 mg/kg and 0.046 mg/kg, respectively, at station MCS3 (Main Canal at Wayside). HPTCL concentration was as high as 0.0039 mg/kg at station BBS1 (Black Bayou at Highway 12). The highest concentration of ENDOSU was 0.0083 mg/kg at station MCS3 (Main Canal at Wayside), but ENDALD was usually below detection limits.

Mean values of the most commonly detected pesticides in surface sediments in the five subwatersheds of Steele Bayou are presented in Figure 15. The following sample sites are included in each of the five subwatersheds: SB1 (SBS1, SBS2, SBS3, SLS1, SLS2, SLS3, and SLS5), MC1 (MCS1 and MCS2), MC2 (MCS3), BB1 (SLS4, GBS1, BBS1, F1, BBS2, and BBS3), BBS2 (BBS4, BBS5, and BBS6). Throughout the subwatersheds, PPDDT and its metabolites were present in the highest average concentrations. The MC2 subwatershed contained the highest concentrations of PPDDT and its metabolites, but all concentrations were low. Concentrations of pesticides were not related to particle size composition or total organic carbon concentration of the sediment. Such lack of correlation can result from localized pesticide inputs into the watershed.

Herbicides, mainly 2,4-D and 2,4-DB, were detected at low concentrations in 6 of the 20 surface sediment sampling sites (Table 13). Sixty percent of the total number of detected herbicides were found in two samples, station SBS3 (Steele Bayou at Hampton) and station BBS4 (Black Bayou at Wilmont). All but one of the herbicide concentrations were below the 95% statistical

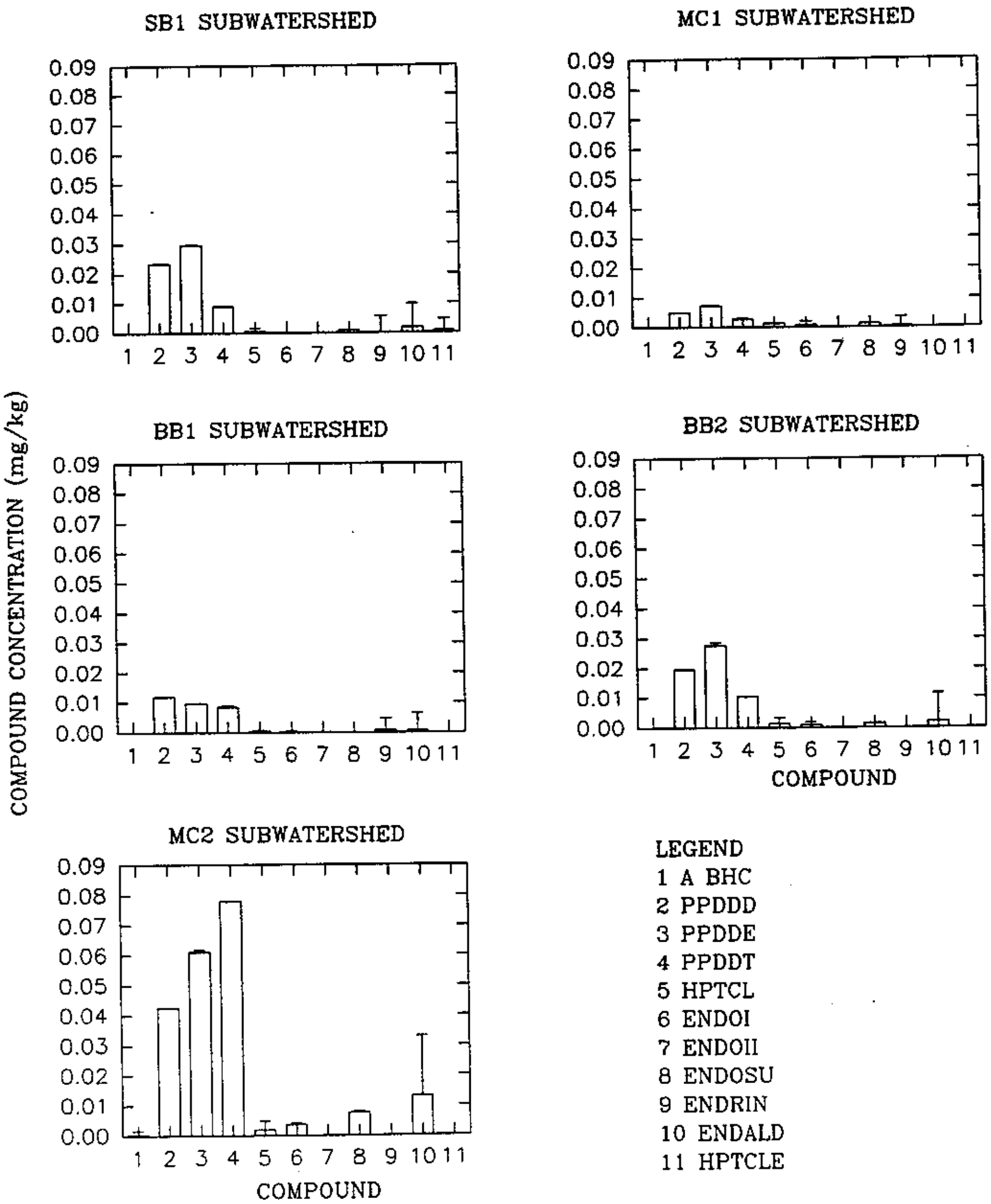

Figure 15. Concentrations (mean and standard error) of the most commonly detected pesticides in surface sediments of the five Steele Bayou subwatersheds

quantitation limit, signifying that the herbicide was found in trace amounts, but that the value was given with a high degree of uncertainty.

Except for PPDDT (and its metabolites) and HPTLC, pesticides and herbicides were rarely found in sediment cores collected from Steele Bayou (Table 14). In general, PPDDE, PPDDD, and PPDDT were detected throughout the sediment profile in low concentrations. The highest concentration was 0.2800 mg PPDDE/kg in the fourth depth segment of the core from station BBS7 (Black Bayou at Leland, Highway 82). The highest concentration of HPTCL was 0.021 mg/kg in the first depth segment of the core from station SLS3 (Silver Lake). PCBs were not detected in the Steele Bayou watershed.

Depth profiles of pesticides most frequently detected in core and surface sediments (PPDDE, PPDDD, and PPDDE) are presented in Figure 16 for the six core samples. Each depth segment is 4 cm, and segments were numbered sequentially from the surface down. Trends included decreasing concentrations with depth in cores from stations BBS3 (Black Bayou at Arcola) and SLS3 (Silver Lake) and peak concentrations at lower depths in cores from stations SBS1 (Rolling Fork at Highway 14) and BBS7 (Black Bayou at Leland). Pesticides in other cores were undetected or near detection limits.

Sediments in the Steele Bayou watershed consisted mainly of fine-grained clay and silt (<50 μm), with two exceptions (Table 15). At station SBS1 (Steele Bayou at Rolling Fork) and in Black Bayou at the wildlife refuge (station SLS5), sediments were 50% or more sand. In core samples, approximately 60 to 90% of the top two to three depth segments from stations SLS1 (Swan lake slough), SLS3 (Silver Lake), SLS5 (Black Bayou in the wildlife refugee), and BBS3 (Black Bayou at Arcola) were fine-grained material. Core sediment from stations SBS1 (Rolling Fork at Highway 14) and BB7 (Black Bayou at Leland) were predominantly sandy in the first two or three depth segments.

The maximum whole-body bioaccumulation potential (WPB) of fish or other aquatic organisms exposed to pesticides contained in surface sediment was estimated using the Tier I evaluation equations given by McFarland and Clarke (1987). These equations describe the partitioning of nonpolar organic compounds such as pesticides between sediment organic carbon and the aquatic organism lipid pools. This is a worst-case prediction of bioaccumulation if sediment is the only source of the contaminant to the organism. Lipid concentrations used in the evaluations are the means of lipid concentrations from fish sampled in and around the Yazoo Refuge in May 1990 (personal communication, Steve Smith, US Fish and Wildlife Service, 7 March 1991). Lipid

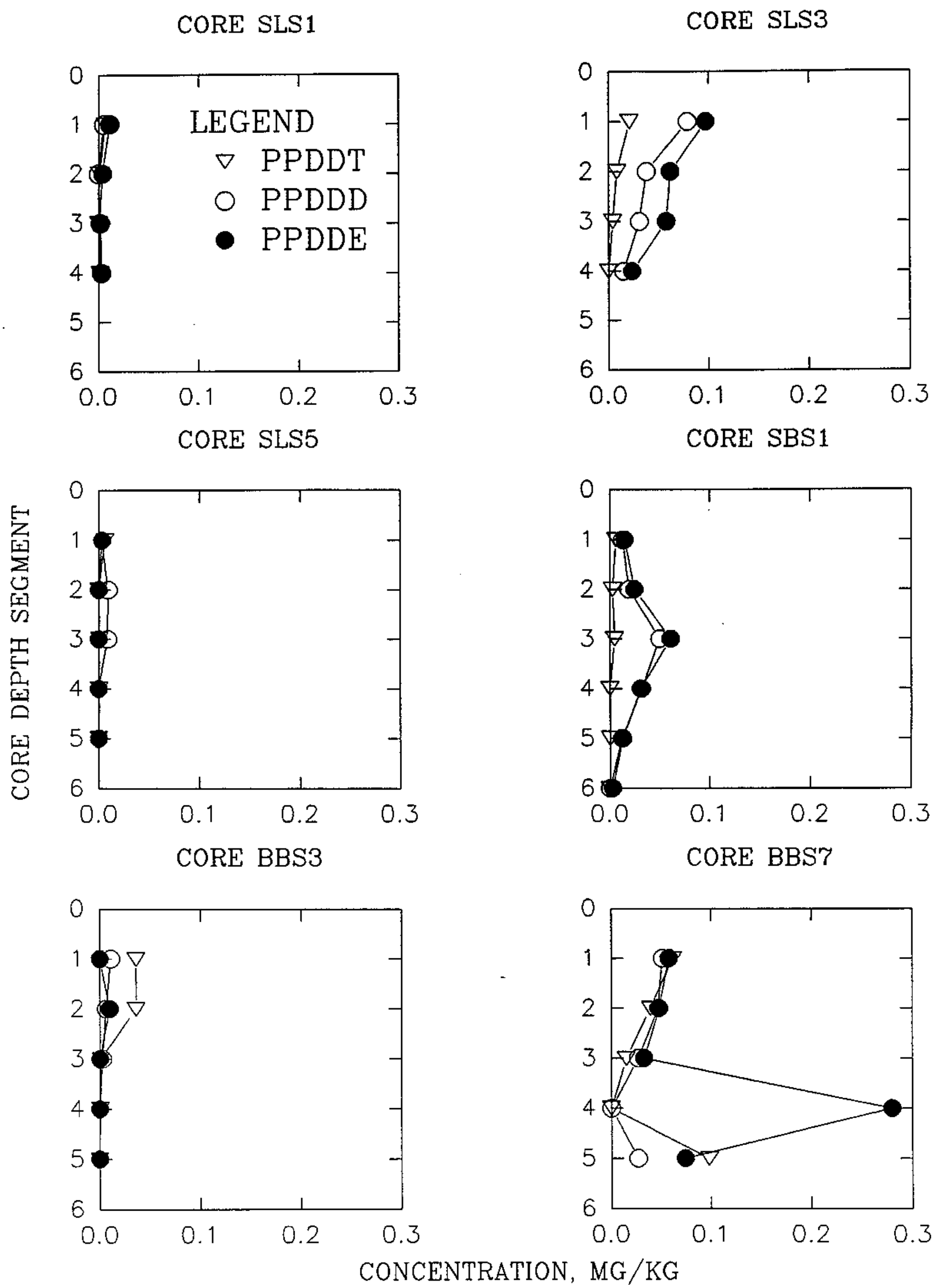

Figure 16. **Concentration profiles of PPDDE, PPDDD, and PPDDT in sediment cores from the Steele Bayou watershed**

concentrations in fish and maximum WPB for the two surface sediment stations with the highest bioaccumulation potential for PPDDE, PPDDD, and PPDDT (MCS3, Main Canal at Wayside, and SLS2, Long Dump) are presented in Tables 16 and 17. Despite low sediment PPDDD, PPDDE, and PPDDT concentrations, high concentrations of these constituents are predicted to occur in fish. Maximum predicted values (Tables 16 and 17) were in general agreement with PPDDE and PPDDT body burdens reported in the upper Steele Bayou watershed for bowfin, carp, smallmouth buffalo, and spotted gar (Ford and Hill 1991). Maximum predicted values of PPDDE for bowfin, carp, smallmouth buffalo, and spotted gar were lower than concentrations measured by Ford and Hill (1991), possibly because of lower sediment pesticide concentrations in the areas sampled during this study.

PART IV: DISCUSSION

Water quality parameters displayed distribution patterns typical of southeastern agricultural watersheds and were generally within criteria established by the State of Mississippi (Mississippi Department of Environmental Quality 1990). Dissolved oxygen was the only parameter to exceed state criteria with instantaneous concentrations below 4.0 mg/l occurring during the summer. However, daily averages of DO concentrations were probably above minimum concentrations due to photosynthetic activity during daylight hours. Specific conductance and dissolved solids did not exceed state criteria for waters classified as fish and wildlife resources. Temperatures were within established criteria (32 °C) except during summer months when natural conditions resulted in temperatures as high as 34.5 °C. Criteria for the remainder of the routine parameters have not been established.

Selected physicochemical and biological parameters displayed dynamic distribution patterns. Diel variations of DO concentrations may be attributed to a highly productive phytoplankton community in the downstream region of the study area. Chlorophyll *a* concentrations greater than 20 µg/l during the summer growing season are further evidence of a highly productive system, particularly in the downstream regions of Main Canal, Black Bayou, and Steele Bayou. Excessive chlorophyll *a* concentrations may be attributed to excessive phosphorus concentrations. Excessive populations of "nuisance" blue-green algae, which can obtain the necessary nitrogen from the atmosphere (Sakamoto 1966), may be attributed to excess phosphorus and low nitrogen concentrations. An organic-rich system is indicated by relatively high dissolved organic carbon concentrations. Pronounced material transport is suggested by relatively high values of total solids and total suspended solids.

Spatial and temporal patterns in parameter concentrations may be attributed to influences of hydrologic events, channel morphometry, hydrology, and local land uses. Influences of hydrologic events were most obvious, with elevated concentrations of suspended material coincident with precipitation and runoff events. Consequently, transport and loading of surface pollutants was greater during periods of runoff. Conditions of high turbidity, total phosphorus, and suspended solids were most prevalent during the "wet season" (late fall to early spring). Conversely, specific conductivity values were highest during summer low-flow periods, indicating dissolved parameters from biological and hydrologic sources (groundwater and agricultural dewatering practices) markedly contributed to seasonal water quality.

During low-flow periods, highly variable distribution of parameter concentrations suggests that local conditions markedly influence water quality. Local conditions affecting water quality include increased hydraulic retention and accumulation of runoff material, as a result of decreased velocities during low flow, and land use of the surrounding watershed. Significantly higher concentrations of solids in the downstream region of Black Bayou suggest accumulation of material from local and upstream subwatersheds. Small-grained sediment remaining in suspension and dense algal populations probably contributed to elevated solids concentrations. Higher concentrations of organic nitrogen and chlorophyll *a* in the downstream region of the watershed during low flow suggest increased biological processing of nutrients. In situ measurements of temperature and dissolved oxygen indicated vertical gradients at the weir pool, Steele Bayou at Rolling Fork (SBS1) (Ashby, unpublished data from the June productivity study). Increased thermal structure would be expected with increased hydraulic retention time in a weir pool resulting in a heat gain, particularly in turbid waters.

Conversely, variability of total and suspended solids was greater during high-flow periods. Increased export of particulate material from the watershed and increased resuspension of channel sediments would be expected during periods of elevated flow. Topography of the watershed is relatively flat, resulting in prolonged runoff events. Consequently, material transport would be directly influenced by the magnitude of localized precipitation events and would be highly variable. Additional variability as the result of local runoff was visually observed during high-flow sampling conducted in January. Runoff from the forested area in the vicinity of Leroy Percy State Park was observed to be more clear (i.e., low suspended solids) and highly colored compared to highly turbid runoff from upstream reaches without significant cover (Ashby, unpublished).

Local influences of riparian vegetation were apparent in evaluation of the phytoplankton community. The presence of a vegetation canopy decreases light availability (Hill and Harvey 1990) and impacts the quality of local runoff (Vitousek and Reiners 1975). In the canopied reach near Leroy Percy State Park, phytoplankton productivity was lower, and chlorophyll *a* concentrations were higher when compared to open reaches. Decreased phytoplankton productivity, coincident with increased chlorophyll *a*, may be an adaptation to decreased light availability. The phytoplankton community was dominated by blue-green species that are capable of nitrogen fixation and thus would have an advantage in a nitrogen-limited system.

Insecticide and herbicide concentrations were detected occasionally in the surface waters of the study area; however, concentrations were generally near detection limits. Detectable concentrations that occurred at various stations in Steele Bayou, Black Bayou, and Main Canal were not concentrated at any particular area, and suggest a ubiquitous distribution.

PPDDD, PPDDE, PPDDT, and heptachlor were the most commonly detected pesticides in surface sediment samples. The highest average concentration of most pesticides was in the MC2 subwatershed. However, all pesticides were detected in low concentrations in surface sediments (<0.1 mg/kg). Sediments were predominantly clay and silt. The range of pesticide concentrations measured in both surface and core samples was substantially lower than the range of values reported by Ford and Hill (1991) for a 1987 sampling of the upper Steele Bayou watershed. The area sampled by Ford and Hill (1991) included Silver Lake Bayou, Black Bayou, and several large agricultural drainage ditches.

Sediments accumulating behind newly constructed weirs should not display concentrations of pesticides substantially different from observed sediment concentrations, which were relatively low. This holds true throughout all areas of the Steele Bayou watershed because of the low pesticide concentrations in surface sediments subject to resuspension and the low concentrations of pesticides in suspended sediments.

Predicted whole body concentrations of PPDDT, PPDDE, or PPDDD did not exceed the US Food and Drug Administration (FDA) Action Level of 5 mg/kg. However, the sum of predicted concentrations of PPDDT, PPDDE, and PPDDD exceeded the FDA action level for carp at station MCS3 (Main Canal at Wayside). Bioaccumulation of PPDDT, PPDDD, and PPDDE from contaminated sediments is favored by high lipid concentrations in fish and low sediment total organic carbon concentrations. Estimated pesticide concentrations in fish indicate that sediment pesticides can potentially affect aquatic biota, even at the low levels found in Steele Bayou sediments. This potential problem will remain endemic to the watershed as long as residues of pesticides such as PPDDT persist in sediments and soils that enter the waterway via runoff.

PART V: CONCLUSIONS

Potential impacts to water quality are related to changes in material transport as a result of proposed flood control measures. Increased retention of particulates would be expected with the addition of low-flow weirs. However, the amount of particulate retention, a function of particle size and flow dynamics, is not quantifiable with the available data. Field observations of runoff events suggest that particulate retention in the drainages is minimal during high flow. Under low-flow conditions, turbid waters were observed in the weir pool, suggesting limited settling of fine, particulate material. During low flow, turbidity was probably due to the small grain size of the suspended material (clays and silts) and the occasional occurrence of algal blooms. Distribution of particulate material was highly variable, and significant reductions of turbidity and suspended solids due to weirs may not be discernible.

The construction of weirs may provide positive and negative impacts on water quality. Increased retention of surface waters due to weirs would increase storage capacity, but pronounced diel fluctuations would be expected in the weir pools. Increased aeration at the outflow of each weir would likely increase dissolved oxygen concentrations in a portion of the downstream reaches of the drainage channels.

In general, water quality at the weir pool (station SBS1, Steele Bayou at Rolling Fork) was not discernibly different from water quality in the drainage basin due to the high variability of physicochemical parameters. Consequently, construction of weirs would likely have minimal impacts on water quality except as described above.

Possibilities of cumulative impacts of a series of low-flow weirs exist, but are not predictable. Intuitively, water clarity may be expected to improve downstream under such a scenario. However, improvements may not be discernible due to minimal retention during high flow and runoff from subwatersheds of each weir. Conversely, increased water clarity coincident with excessive phosphorus concentrations may result in increased algal production.

Hydraulic changes associated with proposed flood control measures should not affect herbicide and pesticide concentrations in sediment and water. Detected pesticides were in low concentrations, and point sources were not discernible.

Sediments accumulating behind newly constructed weirs should not display concentrations of pesticides substantially different from the low existing sediment concentrations. This holds true throughout all areas of the Steele Bayou watershed. Therefore, uptake of pesticides by fish should not be affected by construction of weirs.

Prediction of PPDDD, PPDDE, and PPDDT bioaccumulation by fish (based on the assumption that sediment is the only source of the contaminant to the organism) indicated that bioaccumulation of these pesticides can potentially reach high levels. Addition of weirs to the system should not affect pesticides concentrations in fish because of the limited effect of weirs on pesticide sediment concentrations.

Water quality of the area is determined by land uses. Consequently, the greatest potential for water quality enhancement exists with implementation of Best Management Practices via the appropriate agencies. The current study results are based on assessments from 1 year of data and are reflective of hydrologic conditions for that period of time. Additional monitoring is recommended to document impacts on water quality.

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Table 1

Routine Water Quality Parameters

In Situ Parameters	Physicochemical Parameters
Temperature (Temp)	Total solids (TS)
Dissolved oxygen (DO)	Total suspended solids (TSS)
pH	Turbidity (Turb)
Specific conductance (Cond)	Total organic carbon (TOC)
	Dissolved organic carbon (DOC)
	Organic nitrogen (ON)
	Nitrate/nitrite nitrogen (NO_3/NO_2-N)
	Ammonia nitrogen (NH_3-N)
	Total phosphorus (TP)
	Total dissolved phosphorus (TDP)
	Chlorophyll *a* (Chla) *

* Chlorophyll *a* in the presence of pheophytin *a*.

Table 2

Insecticide and Herbicide Parameters*

Chlorinated Insecticides	Currently Used Insecticides	Herbicides
Aldrin (ALDRIN)	Diazinon (DIAZINON)	2,4-D (2,4-D)
α-BHC (A-BHC)	Ethyl parathion (ETPATH)	2,4-DP (2,4-DP)
β-BHC (B-BHC)	Ethyl trithion (ETTRITH)	2,4,5-T (2,4,5-T)
δ-BHC (D-BHC)	Ethion (ETHION)	2,4,5-TP (2,4,5-TP)
γ-BHC (Lindane)(G-BHC)	Malathion (MALATH)	2,4-DB (2,4-DB)
Chlordane (CHLORDANE)	Methyl parathion (METPATH)	Trifluralin (TRIFLURA)
4,4'-DDD (PPDDD)	Chlorpyrifos (CHLPHFOS)	
4,4'-DDE (PPDDE)	Dicrotophos (DICRPHOS)	
4,4'-DDT (PPDDT)	Azodrin (AZODRIN)	
Dieldrin (DIELDRIN)	Methomyl (METHOMYL)	
Endosulfan I (ENDOI)	Azinphosmethyl (AZPHMETH)	
Endosulfan II (ENDOII)	Sulprofos (SULPROFO)	
Endosulfan sulfate (ENDOSU)	Methamidophos (METAMIPH)	
Endrin (ENDRIN)		
Endrin aldehyde (ENDALD)		
Heptachlor (HPTCL)		
Heptachlor epoxide (HPTCLE)		
Methoxychlor (METOXYCL)		
Toxaphene (TOXAPHEN)		

* Abbreviations used throughout the report are given in parentheses.

Table 3

PCB Congeners for Which Sediments Were Analyzed

Congeners
Aroclor 1016
Aroclor 1221
Aroclor 1232
Aroclor 1242
Aroclor 1248
Aroclor 1254
Aroclor 1260

Table 4

Location and Description of Sampling Sites in the Steele Bayou

Sub-Watershed	Station	Site Location	UTM Coordinates* (X,Y) X	UTM Coordinates* (X,Y) Y	Sample Type
SB1	SBS1	Rolling Fork, Highway 14	691184	3643294	RWQ, S, and C **
	SBS2	Steele Bayou at Hopedale	686178	3648055	SWQ and S
	SBS3	Steele Bayou at Hampton	686979	3656326	RWQ and S
	SBS4	Steel Bayou at Eifling	690352	3661136	SWQ
	SLS1	Swan Lake Slough	687086	3659797	S and C
	SLS2	Long Dump	685650	3663734	S only
	SLS3	Silver Lake	687138	3666894	SWQ, S, and C
	SLS4	# 9 dredge ditch	688561	3668974	SWQ and S
	SLS5	Black Bayou, at wildlife refugee	690446	3666132	S and C
BB1	SBS5	Black Bayou near Percy			
	BBS1	Black Bayou, Highway 12	693652	3670633	RWQ and S
	BBS2	Black Bayou at Estill	692488	3676450	RWQ and S
	BBS3	Black Bayou at Arcola	692805	3683382	RWQ, S, and C
	GBS1	Granicus Bayou, Highway 12	691374	3670780	RWQ and S
	F1	Unnamed ditch near James	691096	3674386	SWQ and S
BB2	BBS4	Black Bayou at Wilmont	692542	3686117	SWQ and S
	BBS5	Black Bayou at Leland	691584	3689679	SWQ and S
	BBS6	Black Bayou at Greenville	687223	3696317	S only
	BBS6.4	Black Bayou near Burdette	690314	3693552	SWQ

(Continued)

* Universal Transverse Mercator.

** RWQ and SWQ indicate routine and supplemental water quality, respectively; S indicates surface sediment; C indicates sediment core.

Table 4 (Concluded)

Sub-Watershed	Station	Site Location	UTM Coordinates (X,Y) X	Y	Sample Type
BB3	BBS7	Black Bayou at Leland, Highway 82	689437	3697552	RWQ, S, and C
	BBS8	Fish Lake near Metcalfe	687092	3699744	SWQ
MC1	MCS1	Pryor Impoundment	685775	3667533	S only
	MCS1.5	Granny Baker Bayou near James			
	MCS1.7	Granicus Bayou near Avon	684431	3673841	SWQ
	MCS2	Granicus Bayou	684031	3677211	SWQ and S
MC2	MCS3	Main Canal at Wayside	685544	3682713	RWQ and S
	MCS3.2	Main Canal SE of Swiftwater	684306	3685886	SWQ
	MCS3.4	Main Canal E of Swiftwater	684012	3689116	SWQ
	MCS3.5	Main Canal near Swiftwater			
	MCS3.6	Main Canal at Greenville	683860	3697125	SWQ
	MCS8	Main Canal at Metcalfe	682920	3703054	SWQ

Table 5

Spatial Variability of Water Quality Parameters within Subwatersheds*

Sub-Watershed	Parameter	June 1990 Survey			January 1991 Survey		
		Mean**	SD	CV	Mean	SD	CV
SB1	TS	346.5 (4)	47.3	13.7	777.0 (3)	580.4	74.7
	TSS	71.2 (4)	14.0	19.6	560.0 (3)	642.4	114.7
	Turb	27.5 (2)	3.5	12.8	253.3 (3)	128.6	50.8
	TOC	7.1 (4)	1.0	13.4	5.6 (3)	0.9	16.1
	DOC	7.1 (4)	1.0	13.7	5.1 (3)	1.1	21.6
	ON	2.82(3)	1.66	58.9	1.80(3)	0.83	45.8
	NO_3/NO_2-N	0.09(2)	0.06	62.9	0.42(3)	0.08	18.3
	NH_3-N	0.04(3)	0.06	134.0	0.18(3)	0.03	14.1
	TP	0.30(4)	0.16	51.7	0.61(3)	0.32	52.3
	TDP	0.08(4)	0.06	76.5	0.08(3)	0.01	7.0
	Chl*a*	18.5 (4)	3.9	20.9	2.00(2)	0.0	0.0
BB1	TS	542.7 (3)	106.1	19.6	683.3 (3)	431.1	63.1
	TSS	166.7 (3)	68.8	41.3	425.0 (3)	280.5	66.0
	Turb	.	.	.	243.3 (3)	123.4	50.8
	TOC	7.7 (3)	1.0	13.4	6.1 (3)	0.47	7.8
	DOC	7.6 (3)	0.9	11.8	6.0 (3)	0.55	9.2
	ON	3.39(3)	0.77	22.9	2.16(3)	0.81	35.9
	NO_3/NO_2-N	0.23(2)	0.28	123.0	0.55(3)	0.11	21.0
	NH_3-N	0.18(3)	0.27	149.0	0.18(3)	0.01	8.2
	TP	0.45(3)	0.12	25.6	0.56(3)	0.27	48.6
	TDP	0.16(3)	0.02	10.8	0.09(3)	0.02	17.2
	Chl*a*	20.0 (3)	8.8	44.4	6.00(3)	4.0	66.7
BB2	TS	386.5 (4)	84.4	21.8	678.2 (4)	187.4	27.6
	TSS	59.5 (4)	15.6	26.2	490.5 (4)	219.3	44.7
	Turb	30.0 (4)	10.8	36.0	297.5 (4)	65.5	22.0
	TOC	6.8 (4)	1.2	17.6	5.1 (4)	0.76	15.0
	DOC	6.8 (4)	1.1	16.2	4.9 (4)	0.64	13.0
	ON	1.63(4)	0.73	44.8	1.7 (4)	0.29	16.6
	NO_3/NO_2-N	0.22(4)	0.18	81.8	0.48(4)	0.03	6.6
	NH_3-N	0.13(3)	0.17	128.0	0.18(4)	0.03	17.8
	TP	0.48(3)	0.36	74.4	0.72(4)	0.16	21.6
	TDP	0.28(4)	0.26	93.5	0.18(4)	0.05	29.7
	Chl*a*	9.3 (4)	7.9	85.7	3.5 (2)	0.7	20.2

(Continued)

* Values are as mg/l except for chlorophyll *a* (μg/l) and turbidity (NTUs).

** Value in parentheses = n.

Table 5 (Concluded)

Sub-Watershed	Parameter	June 1990 Survey			January 1991 Survey		
		Mean**	SD	CV	Mean	SD	CV
BB3	TS	322.5 (2)	29.0	9.0	950.0 (1)	.	.
	TSS	66.0 (2)	2.8	4.3	460.0 (1)	.	.
	Turb	32.0 (2)	0.0	0.0	380.0 (1)	.	.
	TOC	6.4 (2)	0.1	1.1	5.1 (1)	.	.
	DOC	6.4 (2)	0.07	1.1	5.1 (1)	.	.
	ON	1.40(2)	0.29	20.8	2.9 (1)	.	.
	NO_3/NO_2-N	0.16(2)	0.14	88.4	0.56(1)	.	.
	NH_3-N	0.01(2)	0.0	0.0	0.21(1)	.	.
	TP	0.22(2)	0.02	9.9	1.10(1)	.	.
	TDP	0.08(2)	0.01	8.4	0.16(1)	.	.
	Chl*a*	7.5 (2)	3.5	47.1	.	.	.
MC1	TS	341.7 (3)	37.2	10.9	753.0 (2)	342.2	45.4
	TSS	66.7 (3)	24.7	37.0	322.5 (2)	109.6	34.0
	Turb	28.7 (3)	8.1	28.2	285.0 (2)	63.6	22.3
	TOC	5.4 (3)	0.7	12.8	6.2 (2)	0.1	2.3
	DOC	5.3 (3)	0.52	9.8	5.5 (1)	.	.
	ON	1.43(2)	0.61	42.5	2.20(2)	0.99	45.0
	NO_3/NO_2-N	0.24(3)	0.15	61.2	0.62(2)	0.12	19.5
	NH_3-N	0.03(2)	0.01	46.7	0.18(2)	0.01	4.0
	TP	0.27(3)	0.02	9.4	0.90(2)	0.28	30.5
	TDP	0.12(3)	0.03	24.9	0.20(2)	0.04	17.9
	Chl*a*	13.7 (3)	4.9	36.1	55.0 (2)	76.4	138.8
MC2	TS	392.8 (6)	32.1	8.2	691.2 (6)	157.3	22.8
	TSS	72.3 (6)	38.3	53.0	449.8 (6)	163.3	36.3
	Turb	33.3 (6)	15.6	46.8	270.0 (6)	71.3	26.4
	TOC	5.3 (6)	0.7	13.1	4.7 (6)	1.3	28.0
	DOC	5.2 (6)	0.69	13.3	4.5 (6)	1.1	23.7
	ON	1.33(4)	0.38	28.6	1.87(6)	0.31	16.5
	NO_3/NO_2-N	0.32(6)	0.27	83.0	0.54(6)	0.05	9.2
	NH_3-N	0.12(4)	0.12	100.1	0.18(6)	0.02	10.7
	TP	0.34(6)	0.05	15.0	0.78(6)	0.08	10.4
	TDP	0.19(6)	0.05	28.3	0.18(6)	0.03	18.1
	Chl*a*	12.7 (6)	4.6	36.2	1.6 (5)	0.9	55.9

Table 6

Duncan's Multiple Range Test Grouping June 1990 Survey*

Dependent Variable: TS

Duncan Grouping	Mean	n	Subwatershed
A	542.67	3	BB1
B	392.83	6	MC2
B	386.50	4	BB2
B	346.50	4	SB1
B	341.67	3	MC1
B	322.50	2	BB3

Dependent Variable: SS

Duncan Grouping	Mean	n	Subwatershed
A	166.67	3	BB1
B	72.33	6	MC2
B	71.25	4	SB1
B	66.67	3	MC1
B	66.00	2	BB3
B	59.50	4	BB2

Dependent Variable: Org N

Duncan Grouping	Mean	n	Subwatershed
A	3.39	3	BB1
AB	2.82	3	SB1
B	1.63	4	BB2
B	1.43	2	MC1
B	1.40	2	BB3
B	1.33	4	MC2

Dependent Variable: Chla

Duncan Grouping	Mean	n	Subwatershed
A	20.00	3	BB1
A	18.50	4	SB1
AB	13.67	3	MC1
AB	12.67	6	MC2
AB	9.25	4	BB2
B	7.50	2	BB3

(Continued)

* Means with the same letter are not significantly different ($p > 0.05$).

Table 6 (Concluded)

Dependent Variable: TOC

Duncan Grouping	Mean	n	Subwatershed
A	7.7	3	BB1
A	7.1	4	SB1
AB	6.8	4	BB2
AB	6.4	2	BB3
B	5.4	3	MC1
B	5.3	6	MC2

Dependent Variable: DOC

Duncan Grouping	Mean	n	Subwatershed
A	7.6	3	BB1
A	7.1	4	SB1
A	6.8	4	BB2
AB	6.4	2	BB3
B	5.3	3	MC1
B	5.2	6	MC2

Table 7

Duncan's Multiple Range Test Grouping January 1991 Survey*

Dependent Variable: NO_3/NO_2-N

Duncan Grouping	Mean	n	Subwatershed
A	0.62	2	MC1
AB	0.56	1	BB3
AB	0.55	3	BB1
AB	0.54	6	MC2
AB	0.47	4	BB2
B	0.42	3	SB1

Dependent Variable: TP

Duncan Grouping	Mean	n	Subwatershed
A	1.10	1	BB3
AB	0.90	2	MC1
AB	0.78	6	MC2
AB	0.72	4	BB2
B	0.61	3	SB1
B	0.56	3	BB1

Dependent Variable: TDP

Duncan Grouping	Mean	n	Subwatershed
A	0.20	2	MC1
A	0.19	6	MC2
A	0.17	4	BB2
A	0.16	1	BB3
B	0.09	3	BB1
B	0.08	3	SB1

* Means with the same letter are not significantly different ($p > 0.05$).

Table 8

Primary Productivity Values

Station	Initial (mg/l)	Light (mg/l)	Dark (mg/l)	Rate of Net Photosynthesis (mg/l/hr)	Rate of Respiration (mg/l)	Rate of Gross Photosynthesis (mg/l)	Column Depth (m)	Daily Gross Productivity ($mgC/m^2/day$)
SBS1	7.4(0.2)*	16.4(0.3)	5.9(0.3)	1.38	0.23	1.61	0.7	556
BBS1	7.1(0.2)	5.8(0.2)	3.9(0.2)	-0.22	0.53	0.32	0.4	62
BBS2	8.9(0.2)	17.1(0.4)	3.8(0.3)	1.37	0.85	2.2	0.2	295

* Value in parentheses denotes standard deviation.

Table 9

Water Quality at Stations SBS1, BBS1, and BBS2 - Primary Productivity Study*

Parameter	SBS1	BBS1	BBS2
Specific conductance (μmhos/cm)	360	450	380
Total solids (mg/l)	329	665	487
Suspended solids (mg/l)	92	246	130
Total organic nitrogen (mg/l)	1.29	3.67	3.98
Total phosphorus (mg/l)	0.24	0.57	0.44
Total dissolved phosphorus (mg/l)	0.04	0.17	0.17
Total organic carbon (mg/l)	6.5	7.4	8.9
Chlorophyll *a* (μg/l)	14.0	30.7	17.4

* Values represent a single sample collected within the study period.

Table 10

Major Phytoplankton Species, June 1990

SBS1	BBS1	BBS2
Cyclotella *	*Microcystis* *	*Microcystis* *
Oscillatoria *	*Oscillatoria* *	*Oscillatoria* *
Melosira	*Coelastrum*	*Anabaena*
Euglena	*Cyclotella*	*Nitzschia*
Phacus	*Nitzschia*	*Chroococcus*
Coelosphaerium	*Euglena*	*Schroederia*
Cryptomonas	*Schroederia*	*Ankistrodesmus*
Glenodinium	*Tetraedron*	*Euglena*
Scenedesmus	*Melosira*	*Trachelomonas*
	Pediastrum	*Actinastrum*
	Actinastrum	*Melosira*
	Sphaerellopsis	*Coelosphaerium*
		Cryptomonas

* Denotes most abundant species.

Table 11

Insecticide and Herbicide Concentrations in the Surface Water of Steele Bayou*

Parameter	Station												
	SBS1	SBS3	SBS5	BBS1	BBS2	BBS3	BBS7	MCS1.5	MCS3	MCS3.5	GBS1	SLS3	SLS4
April 1990													
G-BHC	<0.00001	**0.00006****	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	mv	mv
D-BHC	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	**0.00001**	<0.00001	<0.00001	<0.00001	<0.00001	mv	mv
PPDDE	<0.00001	<0.00001	<0.00001	<0.00001	**0.00002**	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	mv	mv
PPDDT	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	**0.00003**	<0.00001	<0.00001	<0.00001	<0.00001	mv	mv
HPTCL	<0.00001	<0.00001	<0.00001	<0.00001	**0.00002**	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	mv	mv
Dieldrin	<0.00001	**0.00001**	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	mv	mv
Endrin	<0.00001	**0.00014**	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	mv	mv
DIBUCL-S***	140%	52%	94%	107%	109%	106%	99%	80%	88%	111%	85%	mv	mv
July 1990													
PPDDD	<0.00001	**0.00002**	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
HPTCL	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	**0.00002**	<0.00001	**0.00002**	**0.00003**	<0.00001	**0.00002**	**0.00001**
DIBUCL-S	85%	95%	56%	57%	57%	44%	90%	86%	110%	87%	79%	96%	85%
October 1990													
Diazinon	<0.00001	<0.00001	<0.00001	<0.00001	mv	<0.00001	<0.00001	<0.00001	**0.00010**	**0.00010**	<0.00001	mv	<0.00001
Malathion	<0.00001	<0.00001	<0.00001	<0.00001	mv	<0.00001	<0.00001	<0.00001	**0.00010**	<0.00001	<0.00001	mv	<0.00001
2,4,5,-T	<0.0008	<0.0008	<0.0008	<0.0008	mv	<0.0008	<0.0008	<0.0008	<0.0008	**0.00130**	mv	<0.0008	mv
DIBUCL-S	140%	140%	140%	140%	mv	150%	130%	110%	130%	140%	140%	130%	mv

* Concentrations in mg/l; mv denotes missing value.
** Values above detection limits are in bold.
*** Dibutylchlorendate is a surrogate compound added to check recovery of pesticides and PCBs obtained with the analytical procedures.

Table 12

Concentrations of Pesticides in Surface Sediments from the Steele Bayou Watershed (mg/kg)

Station	Parameter											
	TOC	D-BHC	PPDDD	PPDDE	PPDDT	HPTCL	ENDOI	ENDOII	ENDOSU	ENDRIN	ENDALD	HPTCLE
SBS1	12980	<0.0002	**0.0410***	**0.0550**	**0.0340**	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
SBS2	12230	<0.0002	**0.0110**	**0.0150**	**0.0032**	<0.0002	<0.0002	<0.0002	**0.0008**	<0.0002	**0.0009**	<0.0002
SBS3	10660	<0.0002	**0.0260**	**0.0250**	**0.0110**	**0.0027**	<0.0002	<0.0002	**0.0020**	<0.0002	<0.0002	<0.0002
BBS1	12030	<0.0002	**0.0039**	**0.0045**	<0.0002	**0.0039**	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
BBS2	12240	<0.0002	**0.0073**	**0.0110**	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	**0.0034**	<0.0002	<0.0002
BBS3	10660	<0.0002	**0.0190**	<0.0002	**0.0061**	**0.0019**	<0.0002	<0.0002	<0.0002	<0.0002	**0.0013**	<0.0002
BBS4	13670	<0.0002	<0.0002	**0.0280**	<0.0002	**0.0015**	<0.0002	<0.0002	**0.0007**	<0.0002	<0.0002	<0.0002
BBS5	14450	<0.0002	**0.0340**	**0.0510**	**0.0410**	<0.0002	**0.0036**	**0.0002**	**0.0042**	<0.0002	**0.0076**	<0.0002
BBS6	22300	<0.0002	**0.0400**	**0.0270**	<0.0002	<0.0002	<0.0002	<0.0002	**0.0008**	<0.0002	<0.0002	<0.0002
BB7	19130	<0.0002	**0.0390**	**0.0410**	**0.0780**	**0.0014**	**0.0023**	<0.0002	**0.0067**	<0.0002	**0.0100**	<0.0002
GBS1	11280	<0.0002	**0.0220**	**0.0320**	**0.0270**	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
MCS1	7180	<0.0002	**0.0018**	**0.0033**	<0.0002	<0.0002	<0.0002	<0.0002	**0.0009**	**0.0008**	<0.0002	<0.0002
MCS2	22480	<0.0002	**0.0080**	**0.0110**	**0.0053**	**0.0025**	**0.0016**	<0.0002	**0.0013**	<0.0002	<0.0002	<0.0002
MCS3	11590	**0.0008**	**0.0460**	**0.0810**	**0.0780**	**0.0022**	**0.0048**	<0.0002	**0.0083**	<0.0002	**0.0160**	<0.0002
SLS1	39760	<0.0002	**0.0084**	**0.0430**	<0.0002	<0.0002	<0.0002	<0.0002	**0.0019**	<0.0002	**0.0089**	<0.0002
SLS2	7860	<0.0002	**0.0420**	**0.0470**	**0.0069**	<0.0002	<0.0002	<0.0002	**0.0002**	**0.0010**	<0.0002	<0.0002
SLS3	7890	<0.0002	**0.0400**	**0.0500**	**0.0160**	<0.0002	<0.0002	<0.0002	**0.0033**	<0.0002	**0.0034**	**0.0005**
SLS4	22490	<0.0002	**0.0110**	<0.0002	<0.0002	<0.0002	<0.0002	**0.0004**	<0.0002	<0.0002	<0.0002	<0.0002
SLS5	2430	<0.0002	**0.0008**	**0.0008**	**0.0012**	**0.0013**	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
F1	11910	<0.0002	<0.0002	**0.0050**	**0.0090**	<0.0002	**0.0007**	<0.0002	<0.0002	<0.0002	**0.0011**	<0.0002

* Values above detection limits are in bold.

Table 13

Concentrations of Herbicides in Surface Sediments from the Steele Bayou Watershed (mg/kg)

Station	Parameter					
	2,4-D*	2,4-DP	2,4,5-T	2,4,5-TP	2,4-DB	Trifluralin**
SBS1	BDL	BDL	BDL	BDL	BDL	BDL
SBS2	BDL	BDL	BDL	BDL	BDL	BDL
SBS3	0.099^J	BDL	0.105^J	BDL	0.126^J	BDL
BBS1	BDL	BDL	BDL	BDL	BDL	BDL
BBS2	BDL	BDL	BDL	BDL	BDL	BDL
BBS3	BDL	BDL	BDL	BDL	BDL	BDL
BBS4	0.081^J	BDL	0.064^J	BDL	0.080^J	BDL
BBS5	BDL	BDL	BDL	BDL	0.065^J	BDL
BBS6	BDL	BDL	BDL	BDL	BDL	BDL
BBS7	BDL	BDL	BDL	BDL	BDL	BDL
GBS1	BDL	BDL	BDL	BDL	BDL	0.0038^J
MCS1	BDL	BDL	BDL	BDL	BDL	BDL
MCS2	BDL	BDL	BDL	BDL	BDL	BDL
MCS3	BDL	BDL	BDL	BDL	BDL	BDL
SLS1	BDL	BDL	BDL	BDL	BDL	BDL
SLS2	BDL	BDL	BDL	BDL	BDL	BDL
SLS3	0.078^J	BDL	BDL	BDL	BDL	BDL
SLS4	0.099^J	BDL	BDL	BDL	BDL	BDL
SLS5	BDL	BDL	BDL	BDL	BDL	BDL
F1	BDL	BDL	BDL	BDL	BDL	BDL

* Detection limits varied from 0.064 to <0.176 mg/kg for 2,4-D, 2,4-DP, 2,4,5-T, 2,4,5-TP, and 2,4-DB. For these compounds, a set amount of wet sediment is extracted for analysis by HPLC. Resulting detection limits are a function of the solids content of the wet sediment.

** Detection limit for Trifluralin is <0.002 mg/kg.

^{J} Indicates values below statistical quantitation limits, i.e., present in trace amounts.

Table 14

Concentrations of Organic Carbon and Pesticides in Sediment Cores from the Steele Bayou Watershed (mg/kg)

		Parameter									
Station	Depth	TOC	A-BHC	B-BHC	G-BHC	D-BHC	PPDDD	PPDDE	PPDDT	HPTCL	ENDOI
SBS1	1	9260	<0.0002	<0.0002	<0.0002	<0.0002	**0.0130***	**0.0150**	**0.0062**	**0.0019**	<0.0002
	2	10760	<0.0002	<0.0002	<0.0002	<0.0002	**0.0190**	**0.0250**	**0.0030**	**0.0017**	<0.0002
	3	12820	<0.0002	<0.0002	<0.0002	<0.0002	**0.0500**	**0.0610**	**0.0047**	<0.0002	<0.0002
	4	11750	<0.0002	<0.0002	<0.0002	<0.0002	**0.0320**	**0.0310**	<0.0002	**0.0019**	<0.0002
	5	6790	<0.0002	<0.0002	<0.0002	<0.0002	**0.0120**	**0.0130**	**0.0003**	**0.0026**	<0.0002
	6	9350	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	**0.0028**	<0.0002	**0.0031**	<0.0002
SLS5	1	4810	<0.0002	<0.0002	**0.0004**	<0.0002	**0.0032**	**0.0033**	**0.0064**	**0.0012**	<0.0002
	2	7040	<0.0002	<0.0002	<0.0002	**0.0014**	**0.0096**	<0.0002	<0.0002	**0.0006**	<0.0002
	3	5560	<0.0002	**0.0006**	<0.0002	<0.0002	**0.0089**	<0.0002	**0.0007**	<0.0002	<0.0002
	4	5870	**0.0003**	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	**0.0005**	<0.0010	<0.0002
	5	5740	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
BBS3	1	8770	<0.0002	<0.0002	<0.0002	<0.0002	**0.0110**	<0.0002	**0.0360**	**0.0021**	<0.0002
	2	8170	<0.0002	<0.0002	<0.0002	<0.0002	**0.0066**	**0.0100**	**0.0360**	**0.0200**	<0.0002
	3	5220	<0.0002	<0.0002	<0.0002	<0.0002	**0.0027**	<0.0002	**0.0007**	<0.0002	<0.0002
	4	4650	<0.0002	<0.0002	<0.0002	<0.0002	**0.0004**	<0.0002	**0.0005**	<0.0002	<0.0002
	5	4520	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	**0.0004**	<0.0002	<0.0002	<0.0002
BBS7	1	16500	<0.0002	<0.0002	<0.0002	<0.0002	**0.0510**	**0.0580**	**0.0620**	<0.0002	**0.0029**
	2	8470	<0.0002	<0.0002	<0.0002	<0.0002	**0.0470**	**0.0480**	**0.0390**	**0.0017**	<0.0002
	3	7000	<0.0002	<0.0002	<0.0002	<0.0002	**0.0270**	**0.0330**	**0.0150**	**0.0010**	<0.0002
	4	11220	**0.0006**	<0.0002	<0.0002	<0.0002	<0.0002	**0.2800**	<0.0002	**0.0019**	<0.0002
	5	10940	<0.0002	<0.0002	<0.0002	<0.0002	**0.0270**	**0.0740**	**0.0980**	**0.0010**	<0.0002

(Continued)

* Values above detection limits are in bold.

(Sheet 1 of 4)

Table 14 (Continued)

Station	Depth	Parameter									
		TOC	A-BHC	B-BHC	G-BHC	D-BHC	PPDDD	PPDDE	PPDDT	HPTCL	ENDOI
SLS1	1	33170	<0.0002	0.0026	<0.0002	<0.0002	0.0051	0.0110	0.0068	<0.0002	<0.0002
	2	21730	<0.0002	<0.0002	0.0004	<0.0002	<0.0002	0.0038	0.0012	0.0016	<0.0002
	3	13420	<0.0002	0.0011	<0.0002	<0.0002	0.0021	0.0015	0.0003	0.0017	<0.0002
	4	14510	<0.0002	<0.0002	<0.0002	<0.0002	0.0031	0.0025	0.0015	<0.0002	<0.0002
SLS3	1	21000	<0.0002	0.0046	<0.0002	<0.0002	0.0790	0.0970	0.0210	<0.0002	<0.0002
	2	12380	<0.0002	<0.0002	<0.0002	<0.0002	0.0380	0.0620	0.0086	<0.0002	<0.0002
	3	10510	<0.0002	<0.0002	<0.0002	<0.0002	0.0310	0.0580	0.0043	<0.0002	<0.0002
	4	8500	0.0010	<0.0002	<0.0002	<0.0002	0.0150	0.0240	<0.0002	<0.0002	<0.0002

(Continued)

Table 14 (Continued)

Station	Depth	Parameter				
		ENDOII	ENDOSU	ENDRIN	ENDALD	METOXYCL
SBS1	1	<0.0002	**0.0012**	<0.0002	<0.0002	**0.0015**
	2	<0.0002	**0.0008**	**0.0008**	<0.0002	<0.0002
	3	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
	4	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
	5	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
	6	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
SLS5	1	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
	2	**0.0007**	**0.0026**	<0.0002	**0.0009**	**0.0140**
	3	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
	4	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
	5	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
BBS3	1	<0.0002	<0.0002	<0.0002	**0.0031**	<0.0002
	2	<0.0002	<0.0002	<0.0002	**0.0006**	<0.0002
	3	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
	4	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
	5	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
BBS7	1	<0.0002	**0.0047**	<0.0002	**0.0075**	<0.0002
	2	<0.0002	**0.0032**	<0.0002	**0.0067**	<0.0002
	3	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
	4	<0.0002	<0.0002	<0.0002	<0.0002	0.0052
	5	<0.0002	<0.0002	<0.0002	<0.0002	0.0034

(Continued)

Table 14 (Concluded)

Station	Depth	Parameter				
		ENDOII	ENDOSU	ENDRIN	ENDALD	METOXYCL
SLS1	1	**0.0010**	**0.0009**	<0.0002	**0.0021**	<0.0002
	2	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
	3	<0.0002	<0.0002	**0.0017**	**0.0005**	<0.0002
	4	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
SLS3	1	<0.0002	**0.0061**	<0.0002	**0.0072**	<0.0002
	2	<0.0002	**0.0011**	<0.0002	<0.0002	<0.0002
	3	<0.0002	<0.0002	**0.0012**	<0.0002	<0.0002
	4	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002

Table 15

Particle Size Distribution in Surface and Core Samples from the Steele Bayou Watershed

Station	Depth	% Clay	% Silt	% Sand
SBS1	S*	20.0	17.5	62.5
SBS2	S	35.0	42.5	22.5
SBS3	S	22.5	30.0	47.5
GBS1	S	45.0	40.0	15.0
BBS1	S	65.0	20.0	15.0
BBS2	S	50.0	42.5	7.5
BBS3	S	47.5	37.5	15.0
BBS4	S	55.0	37.5	7.5
BBS5	S	40.0	42.5	17.5
BBS6	S	37.5	25.0	37.5
BBS7	S	35.0	32.5	32.5
SLS1	S	57.5	35.0	7.5
SLS2	S	22.5	52.5	25.0
SLS3	S	22.5	70.0	7.5
SLS4	S	65.0	25.0	10.0
SLS5	S	25.0	25.0	50.0
MCS1	S	47.5	32.5	20.0
MCS2	S	55.0	32.5	12.5
MCS3	S	35.0	47.5	17.5
F1	S	55.0	32.5	12.5
SLS1	1	47.5	30.0	22.5
	2	55.0	32.5	12.5
	3	7.5	22.5	70.0
	4	5.0	22.5	72.5
SLS3	1	40.0	27.5	32.5
	2	37.5	22.5	40.0
	3	35.0	20.0	45.0
	4	25.0	12.5	62.5
SLS5	1	27.5	47.5	25.0
	2	35.0	45.0	20.0
	3	37.5	52.5	10.0
	4	35.0	45.0	20.0
	5	67.5	42.5	0.0

(Continued)

* Surface sediments.

Table 15 (Concluded)

Station	Depth	% Clay	% Silt	% Sand
SBS1	1	15.0	10.0	75.0
	2	20.0	12.5	67.5
	3	27.5	20.0	52.5
	4	32.5	30.0	37.5
	5	35.0	32.5	32.5
	6	30.0	45.0	25.0
BBS3	1	50.0	32.5	17.5
	2	45.0	22.5	32.5
	3	37.5	22.5	40.0
	4	27.5	20.0	52.5
	5	22.5	12.5	65.0
BBS7	1	32.5	15.0	52.5
	2	23.8	18.8	57.4
	3	34.0	38.5	27.5
	4	47.5	30.0	22.5
	5	46.3	33.7	20.0

Table 16

Lipid Concentrations (Percent and Standard Deviation) from Fish in and Around the Yazoo Refuge and Predicted Maximum Whole Body Concentrations (mg/kg) for Station MCS3 (Main Canal at Wayside)

Type Fish	Percent Lipids*	Predicted WPB of PPDDE	Predicted WPB of PPDDD	Predicted WPB of PPDDT	Summation
Carp	7.47 (1.64)	2.08	1.19	2.01	5.28
Spotted gar	5.28 (3.55)	1.47	0.84	1.42	3.73
White crappie	1.98 (0.96)	0.55	0.32	0.53	1.40
Shad	3.21 (1.27)	0.90	0.51	0.86	2.27
Small mouth buffalo	6.78 (1.25)	1.89	1.08	1.82	4.79
Large mouth bass	4.24	1.18	0.67	1.14	2.99
Black crappie	3.03	0.85	0.48	0.82	2.15
Bowfin	4.28 (1.83)	1.19	0.68	1.15	3.02
Fresh water drum	6.54	1.82	1.04	1.76	4.62
Channel Catfish	3.73 (0.94)	1.04	0.59	1.00	2.63

* Data obtained from Steve Smith, US Fish and Wildlife Service, Vicksburg, MS.

Table 17

Lipid Concentrations (Percent and Standard Deviation) from Fish in and Around the Yazoo Refuge and Predicted Maximum Whole Body Concentrations (mg/kg) for Station SLS2 (Long Dump)

Fish Type	Percent Lipids*	Predicted WPB of PPDDE	Predicted WPB of PPDDD	Predicted WPB of PPDDT	Summation
Carp	7.47 (1.64)	1.79	1.60	0.26	3.65
Spotted gar	5.28 (3.55)	1.26	1.13	0.19**	2.39
White crappie	1.98 (0.96)	0.47	0.42	0.07**	0.89
Shad	3.21 (1.27)	0.77	0.69	0.11**	1.46
Small mouth buffalo	6.78 (1.25)	1.62	1.45	0.24	3.31
Large mouth bass	4.24	1.01	0.91	0.15**	2.07
Black crappie	3.03	0.72	0.65	0.11**	1.37
Bowfin	4.28 (1.83)	1.02	0.92	0.15**	1.94
Fresh water drum	6.54	1.56	1.40	0.23	3.19
Channel catfish	3.73 (0.94)	0.89	0.80	0.13**	1.69

* Data obtained from Steve Smith, US Fish and Wildlife Service, Vicksburg, MS.

** Concentrations below 0.2 mg/kg are not counted when adding concentrations to determine if the FDA action level for DDT and its metabolites is exceeded.

APPENDIX A: FIELD AND ANALYTICAL METHODS

APPENDIX A: FIELD AND ANALYTICAL METHODS

Field Methods

Water quality sampling

In situ measurements of temperature, dissolved oxygen, pH, and specific conductance were conducted at each site with a Hydrolab Surveyor (model II, Hydrolab Corporation, Austin, TX). Calibration of the Hydrolab was conducted periodically throughout the sampling period following manufacturer's guidelines (Hydrolab 1985).

Sample collection for water quality analyses was conducted with a clean bucket that was rinsed with sample water at each site prior to sample collection. Samples were collected from the surface at all sites in a manner which did not disturb bottom sediments. Sample processing was conducted onsite, and the sample was continually mixed while subsamples for various analyses were processed. Detailed sample handling is described for each parameter in the Analytical Methods section of this appendix.

Sediment samples

Surface sediment samples were collected using a Ponar sampler. Three samples were taken within 2 m at each designated surface sediment site. Three 5-cm cores were taken from each dredge sample and composited to form one surface sediment sample. The composite was thoroughly mixed, placed into a 1-liter glass jar, and stored on ice for transport. Immediately upon arrival at the WES, samples were stored at 4 °C until analyzed.

Three sediment cores were collected at each designated core site. To obtain the core, a 5-cm diameter aluminum pipe was driven into the bottom sediment as far as it would go or 76 cm, whichever came first. A manual winch was used to extract the aluminum pipe containing the sediment. Comparison of actual core depths with the depth of driven pipe showed that intact cores were obtained by this method. The aluminum pipe was then cut near the sediment surface, taped at both ends, and stored on ice for transport. Upon arrival at WES, sediment cores were extruded from the aluminum pipes, using a plunger and sectioned into appropriate intervals. For each core site, respective depth intervals from each of the three cores were composited, placed in 1-liter glass jars, and stored at 4 °C until analyzed. All cores were sectioned into 10-cm segments.

Analytical Methods - Routine Water Quality Parameters

Water temperature
Method: Thermistor thermometer.
Detection Limit: 0.1° C.
Calibration: National Bureau of Standards certified thermometer.

Dissolved oxygen
Method: Membrane electrode.
Detection limit: 0.1 mg/l.
Calibration: Air calibration.

pH (field measurement)
Method: Electrometric.
Detection Limit: 0.1 pH unit.
Calibration: Buffer solutions of pH 4 and 7.

Specific conductance (field measurement)
Method: Electrometric.
Detection limit: 1 μS/cm.
Calibration: Standard solutions of known conductivity. All readings were corrected for temperature to 25° C.

Solids
Sample preservation: Held in dark at 4° C.

A. Total solids
Method: Gravimetric.
Detection limit: 0.001 g

B. Total suspended solids
Method: Gravimetric, sample filtered onto glass fiber filter.
Detection limit: 0.001 g

Reference: APHA 1980.

Turbidity
Sample preservation: Held in dark at 4° C.
Method: Nephelometric.
Detection limit: 1 NTU.
Calibration: Formazin solutions of known NTU values.

Reference: HACH Corp. 1989.

Carbon
Sample preservation: Held in dark at 4° C.

A. Total organic carbon
Method: Carbon-Infrared.
Detection limit: 0.1 mg/l.

B. Dissolved organic carbon
Method: Carbon-Infrared, filtered through a pre-combusted glass fiber filter.
Detection limit: 0.1 mg/l.

Reference: APHA 1980.

<u>Nitrogen</u>
Sample preservation: Mercuric chloride/sodium chloride. Held in dark at 4° C.

A. Organic nitrogen (total NH4 + organic nitrogen)
Method: I-4552-85, Colorimetric, block digester-salicylate-hypochlorite, automated-segmented flow.
Detection limit: 0.2 mg/l as N.

B. Nitrate/nitrite nitrogen
Method: I-2543-85, Colorimetric, hydrazine reduction-diazotization, automated-discrete, filtered through 0.4-μ filter.
Detection limit: 0.01 mg/l as N.

C. Ammonia nitrogen
Method: I-4522-85, Colorimetric, salicylate-hypochlorite, automated-segmented flow.
Detection limit: 0.01 mg/l as N.

Reference: USGS 1989.

<u>Phosphorus</u>
Sample preservation: Mercuric chloride/sodium chloride. Held in dark at 4° C.

A. Total phosphorus
Method: I-4600-85, Colorimetric, phosphomolybdate, automated-segmented flow.
Detection limit: 0.01 mg/l as P.

B. Total dissolved phosphorus
Method: I-2600-85, Colorimetric, phosphomolybdate, automated-segmented flow, filtered through a 0.4-μ filter.
Detection limit: 0.01 mg/l as P.

Reference: USGS 1989.

Chlorophyll *a*
Sample preservation: Held in dark at 4° C.
Method: Filtered onto a glass fiber filter, DMSO extraction, trichromatic, corrected for pheophytin *a*.
Detection Limit: 1 μg/l.

Reference: APHA 1980

Analytical Methods - Sediments

Total organic carbon

Total organic carbon (TOC) was determined on each sediment or soil sample using Standard Method SWA 9060 (EPA 1986).

Particle size distribution

Particle size distribution was determined on each sediment or soil sample using the method of Day (1956) as modified by Patrick (1958). The particle size fractions determined were clay (<2 μm), silt (2 to 50 μm), and sand (>50 μm).

Analytical Methods - Pesticides and PCBs

Extraction methods

Water samples were extracted according to EPA Standard Method 3510 (EPA 1986). Soil and sediment samples were extracted according to EPA Standard Method 3540 (soxhlet extraction). All chlorinated insecticides, Trifluralin, and PCBs were cleaned up prior to gas chromatographic analysis using EPA Standard Method 3640. Currently used insecticides (phosphorus-containing insecticides) were not cleaned up.

Gas liquid chromatographic analysis

Chlorinated insecticides, Trifluralin, and PCBs were analyzed by gas liquid chromatography (GLC) according to EPA Standard Method 8080 (EPA 1986). Currently used insecticides were analyzed by GLC according to EPA Standard Method 8141. The fully automated Tracor Model 540 Dual Channel Gas Liquid Chromatograph was used with an electron capture detector and a Precision Scientific Auto Sampler (10 μl/injection). Detection limits are given in Table A1.

Analytical Methods - Herbicides

Extraction

Ten grams of wet sample was spiked with 20 ml sodium hydroxide at pH 10-11, and centrifuged to separate the solid and liquid phases. The supernate was removed and cleaned with methylene chloride and NaCl. Ten milliters of the cleaned supernate was acidified to pH 2 and passed through a C18 solid phase extraction cartridge. Herbicides were eluted with 1 ml of HPLC grade acetonitrile.

Analysis

Herbicides were analyzed by high performance liquid chromatography (HPLC). The chromatograph (Waters Associate) contained a photodiode array detector, 600E fluid handling system, WISP autosampler and microprocessor. A modification of the method of Di Corcia, Marchetti, and Samperi (1989) with a reversed-phase C18 column (Waters Novapack 3.9 X 150 mm) was used. The mobile phase was premixed to contain 99.92 percent water and methanol (45:55 percent v/v) and 0.08 percent (v/v) trifluoroacetic acid. The flow rate was 0.8 ml per minute. The herbicides were monitored with the detector set at 228 nm for measuring peak area and at 230 nm for measuring peak height. Sample integration used six multi-component calibration standards. The need to use wet sediment for extraction prior to analysis resulted in detection limits that varied from 0.1 to 0.23 mg/kg, depending upon the solids content of the wet sediment.

Table A1

Detection Limits of Organic Contaminants

Parameter	Detection Limits Water (mg/l)	Detection Limits Soil/Sediment (mg/kg)
Chlorinated insecticides	<0.00001	<0.0002
Currently Used insecticides	<0.00001	<0.0020
Herbicides*	<0.0008	<0.100 - 0.230
PCBs	<0.00001**	<0.0020

* TRIFLURA had a detection limit of <0.00001 mg/l in water.
** Water samples were not analyzed for PCBs.

APPENDIX B: WATER QUALITY DATA

Sub	Sta	Date	SpCond	pH	Temp	DO	NO_3/NO_2	NH_3	ON	TP	TDP	TOC	DOC	Turb	TS	TSS	Chl*a*
SB1	SBS1	900307	130	6.8	14.5	7.8	0.490	0.170	1.33	0.35	0.06	4.10	3.90	140	347	211	4.0
	SBS1	900420	236	7.1	20.5	6.9	0.370	0.170	1.05	0.27	0.04	4.60	4.30	75	276	**121***	4.5
	SBS1	900524	160	6.5	22.0	5.6	1.200	0.180	1.72	0.58	0.13	2.70	1.70	140	**572**	450	3.5
	SBS1	900627	360	mv+	22.0	6.5	<0.02	0.010	1.29	0.24	0.04	6.50	6.50	mv	**326**	**91**	14.0
	SBS1	900724	464	7.1	27.5	4.2	0.470	0.020	1.98	0.16	0.03	4.70	4.70	22	**387**	**27**	23.9
	SBS1	900827	765	7.1	33.0	1.7	0.050	0.020	1.28	0.16	0.09	5.70	5.70	65	**504**	**21**	9.4
	SBS1	900918	795	7.9	27.0	5.5	0.030	0.060	1.54	0.20	0.12	3.90	3.50	35	**570**	**65**	12.0
	SBS1	901023	615	8.0	16.5	7.1	0.040	0.050	1.20	0.14	0.09	6.50	6.50	25	**428**	**50**	8.0
	SBS1	901128	194	7.5	16.0	7.8	2.700	0.130	2.40	0.76	0.30	7.70	7.70	350	**953**	**762**	<1.0
	SBS1	901218	330	7.6	16.0	6.4	mv	0.390	mv	mv	0.05	5.90	5.80	90	**314**	**106**	1.0
	SBS1	910110	mv	mv	mv	mv	0.500	0.180	2.80	0.97	0.09	5.10	4.00	400	**1444**	**1300**	2.7
	SBS1	910212	164	7.2	12.0	7.4	0.410	0.140	1.80	0.38	0.06	6.70	6.70	130	**328**	**174**	2.7
	SBS2	900629	413	7.9	30.5	7.7	0.130	0.110	4.59	0.54	0.16	8.50	8.50	30	294	68	17.4
	SBS3	900307	124	6.9	14.5	7.5	0.520	0.170	1.23	0.40	0.06	4.50	4.30	140	355	134	6.0
	SBS3	900420	215	7.2	19.0	6.2	0.580	0.210	1.29	0.38	0.03	5.60	5.50	100	**330**	**180**	1.1
	SBS3	900524	169	6.6	22.0	5.1	1.300	0.240	1.36	0.44	0.11	3.40	2.30	150	**433**	**233**	1.3
	SBS3	900627	450	mv	27.5	16.1	<0.02	0.010	2.59	0.20	0.04	6.50	6.40	mv	362	58	23.4
	SBS3	900724	566	7.6	29.5	4.8	1.300	0.380	2.22	0.25	0.07	5.40	5.40	38	451	60	14.7
	SBS3	900827	822	7.9	33.0	4.2	0.220	0.020	1.38	0.29	0.20	5.60	5.10	65	563	32	7.4
	SBS3	900918	582	7.4	27.5	4.2	0.210	0.210	1.59	0.36	0.14	5.40	5.10	70	490	124	10.1
	SBS3	901023	352	7.5	16.0	5.6	0.280	0.590	1.80	0.26	0.06	5.80	5.80	82	357	130	8.6
	SBS3	901128	353	7.5	18.0	7.6	1.100	0.420	2.20	0.30	0.08	6.10	6.10	78	367	138	3.6
	SBS3	901218	369	7.8	16.0	7.9	0.430	0.470	1.20	0.34	0.10	6.80	6.80	125	404	172	4.9
	SBS3	910110	mv	mv	mv	mv	0.400	0.200	1.40	0.37	0.08	6.60	6.30	160	387	145	2.7
	SBS3	910212	175	7.2	12.0	7.3	0.400	0.130	1.40	0.38	0.09	6.70	6.70	115	321	152	1.3
	SBS4	900629	521	8.2	32.0	10.3	0.050	<0.01	mv	0.24	0.06	6.90	6.90	25	**404**	**68**	20.7
	SBS4	910112	121	7.1	8.5	9.3	0.350	0.150	1.30	0.48	0.08	5.00	5.00	200	500	235	<1.0
	SLS3	900629	603	8.0	30.0	9.0	0.100	0.610	2.30	0.11	0.07	7.80	7.70	35	389	16	1.3
	SLS3	910112	119	7.3	7.0	9.9	0.410	0.090	1.10	0.35	0.12	7.40	7.40	140	315	75	1.1
	SLS4	900629	236	7.4	28.0	1.6	0.060	<0.01	mv	0.17	0.04	5.50	3.20	7	209	50	15.4
	SLS4	910112	166	7.3	8.0	8.2	0.080	0.050	0.88	0.17	0.06	6.30	6.30	75	219	20	<1.0

* Bold values denote mean of laboratory duplicate analyses.

+mv denotes missing value.

Sub	Sta	Date	SpCond	pH	Temp	DO	NO_3/NO_2	NH_3	ON	TP	TDP	TOC	DOC	Turb	TS	TSS	Chl*a*
BB1	SBS5	900307	167	7.4	15.5	8.2	0.600	0.120	1.58	0.41	0.08	4.50	4.30	140	375	244	7.4
	SBS5	900420	233	7.9	19.5	7.1	0.840	0.120	3.33	1.10	0.07	5.70	5.50	260	1008	864	10.7
	SBS5	900524	209	7.2	22.0	5.8	1.300	0.210	1.59	0.45	0.11	4.10	3.00	150	453	294	3.0
	SBS5	900628	560	mv	22.5	4.7	0.430	0.490	2.51	0.34	0.14	6.90	6.90	mv	476	124	13.4
	SBS5	900724	623	8.0	27.5	6.6	1.500	0.280	2.92	0.36	0.12	5.40	5.40	60	562	132	33.4
	SBS5	900827	778	8.2	30.0	6.4	0.080	0.030	1.37	0.55	0.24	6.40	5.00	60	606	112	3.3
	SBS5	900918	610	7.7	25.5	5.5	0.320	0.060	1.94	0.33	0.18	6.10	6.10	65	520	124	8.0
	SBS5	901023	950	8.3	15.5	6.8	0.780	0.070	6.90	0.61	0.16	9.50	8.30	78	715	126	105.3
	SBS5	901128	470	7.6	17.0	6.9	0.590	0.100	2.40	0.50	0.24	8.80	8.60	140	592	280	15.2
	SBS5	901218	442	7.7	16.5	6.6	2.200	0.170	2.40	1.80	1.10	8.70	8.70	195	500	232	7.0
	SBS5	910110	mv	mv	mv	mv	0.570	0.170	3.10	0.86	0.07	5.90	5.60	380	1150	715	6.7
	SBS5	910212	196	7.6	11.0	9.3	0.430	0.170	1.50	0.34	0.09	7.30	7.20	95	308	130	12.0
	BBS1	900307	197	7.6	15.0	8.5	0.530	0.110	1.59	0.39	0.08	4.40	4.00	120	365	223	10.0
	BBS1	900419	215	7.4	20.5	6.8	1.000	0.130	1.42	0.46	0.05	5.20	5.20	95	487	326	6.7
	BBS1	900524	246	7.0	25.0	5.1	1.400	0.240	1.46	0.38	0.11	4.50	4.50	130	433	246	2.5
	BBS1	900627	450	mv	23.0	6.4	0.030	0.030	3.67	0.57	0.17	7.40	7.40	mv	665	246	30.7
	BBS1	900724	606	8.1	30.0	8.5	1.700	0.500	3.50	0.42	0.11	6.20	6.20	mv	615	204	40.8
	BBS1	900827	773	8.4	32.0	10.4	0.080	0.020	1.58	0.34	0.21	5.40	5.20	65	600	116	12.0
	BBS1	900918	605	7.6	28.0	6.0	0.270	0.060	1.44	0.32	0.16	6.60	6.30	65	527	130	10.9
	BBS1	901023	490	8.2	18.0	10.4	0.450	0.080	3.20	0.34	0.09	8.90	8.00	97	mv	mv	25.4
	BBS1	901128	444	7.6	17.0	6.1	0.250	0.060	1.70	0.37	0.10	6.50	6.50	78	539	234	8.0
	BBS1	901218	508	7.7	16.5	7.1	0.740	0.230	2.80	0.51	0.04	8.40	8.40	155	589	284	14.8
	BBS1	910110	mv	mv	mv	mv	0.430	0.200	1.60	0.34	0.10	6.60	6.60	140	300	155	10.7
	BBS1	910212	215	7.6	12.0	9.3	0.480	0.050	1.50	0.34	0.08	6.80	6.80	100	400	144	10.7
	BBS2	900307	219	7.6	15.0	8.4	0.600	0.150	1.55	0.33	0.09	4.60	4.00	95	332	165	21.7
	BBS2	900419	253	7.9	20.0	8.1	0.850	0.060	0.82	0.36	0.07	5.20	5.20	95	340	150	8.6
	BBS2	900524	246	7.2	25.0	5.8	1.600	0.190	1.21	0.28	0.13	5.40	5.20	100	266	100	mv
	BBS2	900627	380	mv	26.0	9.4	<0.02	0.020	3.98	0.44	0.17	8.90	8.60	mv	487	130	17.4
	BBS2	900724	537	8.0	31.0	10.1	2.100	0.540	2.36	0.29	0.14	6.20	6.10	45	461	82	17.4
	BBS2	900827	759	8.4	32.5	11.2	0.130	0.020	1.48	0.31	0.20	6.10	5.70	45	552	74	8.7
	BBS2	900918	614	7.9	29.0	6.9	0.310	0.090	1.61	0.40	0.24	7.30	7.30	55	502	112	8.4
	BBS2	901023	455	8.4	20.5	11.2	0.290	0.110	1.90	0.27	0.13	6.00	6.00	75	mv	mv	13.9
	BBS2	901128	529	8.2	18.0	10.6	0.610	0.020	2.80	0.32	0.10	10.00	9.60	85	526	168	17.4
	BBS2	901218	248	7.4	16.0	6.6	1.100	0.210	1.90	0.59	0.15	7.50	7.50	180	455	284	11.4
	BBS2	910110	mv	mv	mv	mv	0.660	0.180	1.80	0.47	0.09	5.70	5.70	210	600	405	2.7
	BBS2	910212	235	7.7	13.0	10.2	0.590	0.074	1.60	0.33	0.08	6.90	6.80	75	301	118	10.7

Sub	Sta	Date	SpCond	pH	Temp	DO	NO_3/NO_2	NH_3	ON	TP	TDP	TOC	DOC	Turb	TS	TSS	Chl*a*
BB1	GBS1	900307	240	7.6	15.0	9.5	0.460	0.220	2.38	0.30	0.05	5.90	5.10	105	374	178	16.4
	GBS1	900419	227	7.9	20.5	9.6	0.620	0.040	1.06	0.36	0.07	7.50	7.30	110	349	148	13.4
	GBS1	900524	145	6.9	25.0	5.8	1.200	0.410	1.79	0.56	0.07	5.20	4.70	120	611	432	1.9
	GBS1	900629	704	7.9	27.5	5.5	0.530	0.130	1.57	0.15	0.05	7.40	7.00	25	516	40	13.4
	GBS1	900724	741	7.9	28.5	6.1	0.850	0.990	7.01	0.14	0.07	6.60	6.40	45	556	82	4.0
	GBS1	900827	945	8.2	28.5	7.7	0.140	0.060	1.14	0.23	0.10	4.30	4.20	38	635	72	4.0
	GBS1	900918	818	7.6	27.0	6.2	0.360	0.970	2.33	0.35	0.15	6.70	6.70	55	630	156	6.7
	GBS1	901023	686	8.0	18.0	10.2	0.020	0.020	2.40	0.23	0.12	6.50	6.50	17	475	30	21.5
	GBS1	901128	575	7.7	17.0	7.5	0.580	0.520	3.10	0.32	0.08	11.00	11.00	65	517	132	22.7
	GBS1	901218	494	7.6	16.0	7.0	1.000	0.060	1.90	0.31	0.07	9.40	9.40	130	514	200	7.4
	GBS1	910112	158	7.2	8.5	9.8	0.640	0.260	1.70	0.45	0.06	5.40	5.40	280	600	280	3.2
	GBS1	910212	185	7.4	12.0	9.4	0.430	0.100	1.50	0.28	0.06	8.20	8.20	105	200	120	13.4
	F1	900629	560	7.8	26.5	5.1	0.350	0.730	2.80	0.24	0.05	7.30	7.30	20	410	56	25.4
	F1	910112	215	7.2	8.0	8.7	0.660	0.470	2.30	0.42	0.07	5.80	5.80	260	577	315	8.7
BB2	BBS3	900307	225	7.8	15.5	9.0	0.600	0.190	1.71	0.35	0.09	4.60	4.10	95	353	185	7.7
	BBS3	900419	286	7.7	20.5	8.5	0.820	0.080	0.72	0.34	0.10	4.90	4.80	40	318	130	6.4
	BBS3	900524	220	7.5	27.0	6.5	1.800	0.140	1.46	0.37	0.14	5.30	5.30	110	321	106	7.9
	BBS3	900628	600	8.4	34.5	11.2	0.060	0.010	2.39	0.40	0.23	7.90	7.90	30	450	62	19.4
	BBS3	900724	557	8.2	31.0	8.9	1.200	0.380	1.72	0.32	0.22	6.10	6.00	35	438	46	11.6
	BBS3	900827	640	8.4	33.0	16.6	0.110	0.040	3.16	0.41	0.19	6.30	6.20	8	558	136	23.8
	BBS3	900918	651	8.0	29.5	8.9	0.320	0.080	1.72	0.57	0.39	8.30	8.30	45	504	78	8.5
	BBS3	901024	699	8.2	12.5	9.0	0.490	1.700	7.80	0.98	0.45	8.90	7.60	71	550	118	58.4
	BBS3	901129	186	7.2	13.0	6.2	1.500	0.200	2.50	0.86	0.25	7.90	7.90	245	695	490	17.4
	BBS3	901219	176	7.2	14.0	6.6	1.000	0.110	1.90	0.67	0.23	8.50	8.50	225	499	300	1.7
	BBS3	910111	94	7.2	10.0	9.5	0.440	0.160	1.50	0.54	0.12	5.70	5.30	250	502	305	<1.0
	BBS3	910212	277	7.8	12.0	9.2	0.570	0.200	1.80	0.33	0.09	7.30	7.20	62	320	118	17.4
	BBS4	900628	615	8.3	34.0	8.6	0.380	0.320	2.10	0.87	0.65	7.80	7.50	20	468	58	12.0
	BBS4	910111	85	7.0	10.0	9.4	0.450	0.150	1.50	0.67	0.15	5.50	5.40	240	572	372	4.0
	BBS5	900628	404	7.8	31.5	5.5	0.380	0.060	0.84	0.17	0.14	5.60	5.60	25	324	40	1.3
	BBS5	910111	77	7.0	9.5	9.5	0.470	0.170	1.80	0.77	0.18	5.00	5.00	320	712	485	mv
	BBS6.4	900628	362	8.1	34.0	8.5	0.070	<0.01	1.20	mv	0.08	6.00	6.00	45	304	78	5.4
	BBS6.4	910111	60	6.8	9.5	9.7	0.510	0.220	2.10	0.91	0.24	4.00	4.00	380	927	800	3.5

Sub	Sta	Date	SpCond	pH	Temp	DO	NO_3/NO_2	NH_3	ON	TP	TDP	TOC	DOC	Turb	TS	TSS	Chla
BB3	BBS7	900308	192	6.8	14.5	8.7	0.410	0.170	1.93	0.55	0.10	4.80	3.40	170	563	406	3.7
	BBS7	900419	304	7.8	16.5	8.3	0.330	0.100	0.68	0.23	0.04	4.40	mv	60	281	91	5.9
	BBS7	900525	231	7.0	23.5	6.1	2.200	0.110	1.19	0.23	0.06	4.20	4.00	80	278	108	6.4
	BBS7	900628	381	8.2	33.0	7.6	0.260	0.010	1.19	0.20	0.09	6.40	6.40	32	302	64	10.0
	BBS7	900725	493	8.4	28.5	12.0	0.300	0.200	1.30	0.21	0.08	4.50	4.50	8	226	32	18.7
	BBS7	901024	254	7.1	11.5	4.1	0.300	0.130	1.10	0.30	0.20	4.20	4.20	22	200	38	mv
	BBS7	901129	139	7.0	12.0	5.5	0.300	0.110	1.60	0.54	0.14	6.80	6.80	160	416	240	6.7
	BBS7	901219	114	7.1	13.0	6.5	1.200	0.110	2.60	0.96	0.14	6.70	6.70	370	824	610	3.9
	BBS7	910111	57	6.8	9.5	8.8	0.560	0.210	2.90	1.10	0.16	5.10	5.10	380	950	460	<1.0
	BBS7	910212	203	7.5	12.0	7.6	0.450	0.160	1.20	0.34	0.05	5.20	5.20	105	307	146	6.2
	BBS8	900628	450	8.2	32.5	8.0	0.060	0.010	1.60	0.23	0.08	6.30	6.30	32	343	68	5.4
MC1	MCS1.5	900308	138	7.4	14.5	9.1	0.420	0.180	3.52	0.81	0.08	4.50	3.70	355	1165	458	1.6
	MCS1.5	900420	338	7.6	19.5	6.3	0.620	0.090	0.61	0.22	0.07	4.90	4.50	50	286	54	8.6
	MCS1.5	900524	241	7.0	23.5	5.0	1.400	0.280	1.32	0.35	0.11	4.90	4.90	90	320	128	4.8
	MCS1.5	900629	373	7.9	29.5	6.0	0.320	0.040	1.86	0.27	0.09	6.20	5.90	23	307	60	17.4
	MCS1.5	900724	393	7.8	29.0	3.9	1.000	0.760	1.44	0.21	0.08	4.40	4.40	45	317	58	14.4
	MCS1.5	900827	582	8.2	30.0	4.4	0.060	0.020	1.18	0.32	0.19	4.90	4.80	19	389	30	4.7
	MCS1.5	900918	312	7.4	27.0	2.2	0.060	0.050	1.65	0.33	0.15	6.80	6.80	40	265	58	11.1
	MCS1.5	901023	222	7.5	15.5	5.2	0.200	0.190	1.40	0.22	0.18	3.40	1.20	67	262	116	8.0
	MCS1.5	901128	239	7.6	18.0	7.5	0.160	0.040	1.60	0.28	0.10	5.80	5.80	55	274	130	8.0
	MCS1.5	901218	432	7.6	16.0	5.7	0.740	0.300	1.30	0.55	0.16	5.00	5.00	170	516	232	5.4
	MCS1.5	910110	mv	mv	mv	mv	0.700	0.180	2.90	1.10	0.17	6.10	5.50	330	995	400	109.6
	MCS1.5	910212	150	6.8	12.0	6.2	0.200	0.090	1.10	0.34	0.08	6.50	6.50	89	238	68	7.4
	MCS1.7	900628	478	8.0	30.5	6.9	0.070	0.020	1.00	0.24	0.13	5.00	5.00	25	337	46	8.7
	MCS2	900628	477	8.2	31.0	10.3	0.330	<0.01	mv	0.29	0.15	5.00	5.00	38	381	94	16.7
	MCS2	910112	mv	7.1	8.5	9.3	0.530	0.170	1.50	0.71	0.22	6.30	mv	240	511	245	1.3
MC2	MCS3	900308	152	7.2	14.0	8.4	0.690	0.410	3.19	0.79	0.12	5.00	3.60	250	819	549	2.7
	MCS3	900419	434	7.8	19.0	7.2	0.560	0.160	0.64	0.28	0.14	4.80	4.70	50	366	88	2.4
	MCS3	900524	305	7.6	24.5	6.8	1.100	0.180	1.12	0.30	0.12	4.60	4.60	65	326	120	4.6
	MCS3	900628	527	8.1	29.5	6.6	0.750	0.020	1.88	0.33	0.16	6.00	5.90	55	437	114	16.0
	MCS3	900724	278	7.9	30.0	8.0	0.900	0.650	10.35	0.33	0.19	10.00	10.00	55	296	88	11.4
	MCS3	900827	578	8.5	32.0	12.0	0.080	0.020	1.18	0.36	0.22	5.10	5.00	10	416	73	6.7
	MCS3	900918	422	8.2	29.5	8.8	0.180	0.090	1.81	0.63	0.35	7.40	7.40	80	412	139	16.0
	MCS3	901024	346	7.9	14.0	7.0	0.570	0.250	1.20	0.53	0.31	8.10	5.00	45	308	81	2.0

Sub	Sta	Date	SpCond	pH	Temp	DO	NO_3/NO_2	NH_3	ON	TP	TDP	TOC	DOC	Turb	TS	TSS	Chl*a*
MC2	MCS3	901129	238	7.2	13.0	5.0	1.300	0.920	2.30	0.76	0.34	8.50	8.40	125	412	194	10.7
	MCS3	901219	158	7.1	12.8	6.6	1.100	0.110	2.30	0.88	0.24	7.80	7.80	305	639	276	1.3
	MCS3	910111	109	7.1	10.0	9.3	0.540	0.160	1.70	0.73	0.22	6.30	5.60	280	568	322	1.8
	MCS3	910212	398	7.7	12.0	8.6	0.300	0.190	0.79	0.26	0.11	5.10	5.10	40	316	66	4.7
	MCS3.2	900628	524	8.1	31.0	9.0	0.520	<0.01	mv	0.32	0.16	5.90	5.80	45	414	106	20.0
	MCS3.2	910111	107	7.0	10.5	8.3	0.590	0.160	1.50	0.80	0.23	6.30	6.00	280	621	355	2.7
	MCS3.4	900628	480	8.3	29.5	5.7	0.040	<0.01	mv	0.40	0.22	5.30	5.30	40	411	94	13.4
	MCS3.4	910110	116	6.9	10.0	8.9	0.610	0.210	2.00	0.82	0.19	4.30	4.30	240	700	480	1.1
	MCS3.5	900308	98	7.4	14.0	8.9	0.360	0.190	2.71	0.89	0.15	4.90	3.20	150	610	472	1.0
	MCS3.5	900419	447	7.8	18.5	8.0	0.400	0.160	0.49	0.27	0.10	3.90	4.00	32	337	54	2.4
	MCS3.5	900524	329	7.4	26.0	7.3	1.000	0.130	1.27	0.34	0.12	4.20	4.10	70	380	159	3.6
	MCS3.5	900628	553	8.4	29.0	13.0	0.130	0.050	1.05	0.41	0.27	4.80	4.50	17	369	26	9.4
	MCS3.5	900725	298	mv	27.5	4.2	0.280	0.130	1.87	0.33	0.14	4.90	4.90	8	358	40	28.5
	MCS3.5	900828	646	8.1	25.5	5.7	0.140	0.180	0.73	0.55	0.43	3.70	3.70	33	440	58	2.0
	MCS3.5	900919	642	8.0	24.0	4.8	0.310	0.410	0.89	0.80	0.67	3.90	3.90	34	447	42	1.8
	MCS3.5	901023	433	9.1	23.5	18.5	0.460	0.160	1.20	0.61	0.43	5.60	5.50	28	300	28	7.2
	MCS3.5	901129	208	7.3	12.0	7.0	0.830	0.220	1.60	0.66	0.26	6.90	6.90	150	459	270	2.7
	MCS3.5	901219	176	7.3	12.0	7.6	1.200	0.090	2.20	0.81	0.18	6.50	6.50	305	683	512	1.6
	MCS3.5	910111	141	7.1	10.0	9.1	0.540	0.180	1.80	0.70	0.19	4.20	4.20	160	613	332	3.7
	MCS3.5	910212	432	7.8	12.5	8.3	0.210	0.220	0.78	0.30	0.17	4.50	4.50	25	310	42	mv
	MCS3.6	900628	533	7.8	27.0	8.6	0.260	0.290	1.10	0.32	0.19	4.20	4.40	18	357	30	9.4
	MCS3.6	910111	137	6.8	10.0	9.4	0.490	0.190	1.80	0.73	0.16	3.80	3.80	280	645	455	<1.0
	MCS8	900628	505	7.5	28.0	3.7	0.220	0.120	1.30	0.28	0.12	5.60	5.30	25	369	64	9.4
	MCS8	910111	85	6.9	11.0	9.8	0.490	0.190	2.40	0.92	0.14	3.20	3.20	380	1000	755	1.3